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ERRATUM

Page 226, line 20: For $B = f(\imath \times t)^p$ read $B = f(\imath \times t^p)$.

PALEONTOLOGY.—*The role of the individual in evolution.*[1]
   GEORGE GAYLORD SIMPSON, American Museum of Natural History.   (Communicated by C. LEWIS GAZIN.)

"All is for individuals."[2]

Whatever happens in organic evolution, or indeed within the whole realm of the biological sciences, happens to an individual. Genetic mutations occur in individuals. Individuals struggle for existence and fail or succeed according to their equipment and circumstances. It is individuals that reproduce and that exercise such selection of a mate as may be possible to them. These facts are so evident that it may not seem worth while to state them, and similar statements so exhaust the basic aspects of evolutionary theory that it may seem impossible to say more about the role of the individual in evolution. Nevertheless such statements of the obvious are not needless, because the obvious is so often forgotten, nor do they exhaust the subject, because it has scientific, philosophical, and social ramifications that are both subtle and complex.

Difficulty is encountered at the outset in attempts to define an individual. I am sure that I am an individual, and I am willing to grant the same status to a dog, an oyster, or a pine tree. This apparently simple concept, however, begins to encounter difficulties if a colonial coral is considered and to break down altogether on the problem of whether a lymphocyte is an individual. There are different categories of individuals and different degrees of individuality. Their classification and definition could be discussed for hours, and the discussion would probably produce more obscurity than light. Let us avoid this confusion by using the word "individual" in a commonplace sense as an organically continuous living structure capable of reacting independently and as a whole.

There has been evolution toward more and toward less individual-

[1] Address delivered before the Paleontological Society of Washington, November 20, 1940   Received November 30, 1940
[2] The section epigraphs are all from Walt Whitman's poem "As I Sat Alone by Blue Ontario's Shores."

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ity. A solitary protozoan, such as an amoeba, is fully individual under our definition, but one cell of a protozoan colony, as in *Volvox*, is less individual. As metazoans arise by cellular differentiation, the protozoan individuality of the single cell is effectively lost, and the metazoan structure becomes itself fully individual in the same sense as the solitary protozoan but on a new and different level. In colonies of essentially similar but organically continuous metazoans, as in many corals, the metazoan individuality begins to merge into one of different level. Finally a stage may be reached, as in *Physalia* and its allies, in which the united metazoan zooids are differentiated in function and structure and have almost entirely abdicated their individualities in favor of what might be called a hyperzoan individuality. Here there appears to be a true emergence of individuality belonging to the colony rather than to the zooids, in the same way that metazoan individuality belongs to the animal and not to its constituent cells.

Hyperzoan individuality is a rare evolutionary development. The vast majority of living things have stopped short at the metazoan level, and their further progressive evolution has been an intensification of individual integration and complication on that level. This is preëminently true of the vertebrates and among them of the line leading to man, which has shown neither the trend nor the potentiality of developing hyperzoan individuality. Certain social groups, particularly among insects, present evident analogies with hyperzoan individuals, and there has been a strong recent tendency to consider human society as possessing this sort of individuality, but in a biological sense this is wholly false except as a figure of speech. One level of individuality can arise only to the degree that the subordinate level is suppressed. Most animal and all human social groups are collectivities the members of which retain complete metazoan individuality.

This distinction between group and individual is fundamental and has implications of the greatest importance, extending even into the political sphere. The subject will be developed further in the following pages, and these implications will be explored when a broader basis for them has been laid.

THE INDIVIDUAL, DARWINISM, AND GENETICS

"For the great idea, the idea of perfect and free individuals."

In a Lamarckian view of evolution, the individual is all-important. He is the master of his fate in the broadest sense, and individual activities may wholly determine the course of evolution. The individual acts, learns, and strives; his characteristics are thereby altered, and

some part of this modification is transmitted to the next generation. This theory dies hard, and paleontologists seem inclined to cling to some aspects of it more than neobiologists, but it probably must be abandoned. No means for the transmission of such individually acquired modifications have been discovered, and long experimentation has failed to reveal unquestionable evidence of its real occurrence. It now appears that new characters can arise only in the germ plasm and that their rise is little or not influenced by any purely individual factor.

Under more strictly Darwinian theories and the genetic theories that partly supplement and partly supplant Darwinism, new characters in phylogeny arise at random, at least in the sense that their appearance is sporadic and that the present state of our knowledge does not enable us to predict them individually. The individual seems at first sight to have little to do with evolution under these circumstances, which make the emergence of novelty seem as impersonal as the fatality of a bolt of lightning striking a crowd. It may be only ignorance that makes us think that this is true, but even if it be granted, the individual is still left an essential role in evolutionary theory. The fate of mutations and their genetic combination and segregation are aspects of evolution quite as important as their origin and more approachable, and here the individual is highly important.

The Darwinian theory of natural selection is often presented as primarily a pruning process. Given the fact that hereditary variation occurs, whatever its basis and origin, this viewpoint is that the direction of evolution is largely controlled by negative factors: by the elimination of some variations, singly or in combination. Even those geneticists who are least neo-Darwinian usually recognize selective elimination as one crucial factor in evolution. Here the individual's role is stellar but tragic. His essential part in evolution is to die. If selection is operative, death is not a random occurrence in which the individual counts for nothing, but must be correlated with individual characteristics and the study of the selective process must be directed toward individuals.

Some individuals are always less fit than others, or carry genes that are deleterious under the environmental conditions available to the species. As Dobzhansky says, "It is the loss of these individuals that guards the species as a whole from extinction." And he adds, "The general picture of the mechanism of evolution thus arrived at will certainly be far from pleasing to those who regard nature as an embodiment of kindness. The writer must confess that this picture is

not pleasing to him either. The words 'good' or 'bad' are not to be found, however, in the scientific lexicon."

The selective process, however, is not concerned with elimination only, and gloomy concentration on the death of the individual and the extinction of the species leaves out what Darwin himself so well emphasized as the essence of natural selection, that is, the survival of the fittest. It is no truer to say that the individual's role is to die than to say that its role is to survive. The species is a sum or collectivity of individuals, and it is an entity only in this sense, not in the sense of having a sort of superindividuality. Its survival similarly is the sum of individual survivals. Survival, along with reproduction, which is an aspect of survival, is the individual's business.

The individual's role here, one might say his duty if the word can be used without anthropomorphic implications, may be represented in terms of striving to obtain satisfaction. On the lowest level, active bodily metabolism and reproduction have come to be basic satisfactions, simply because they do have this survival value. It may be objected that satisfaction is an emotion and that the vast majority of living organisms feel no such thing, but the difficulty is semasiological rather than conceptual. In every living thing there is at least an impulsion or need that is eased by such fulfillment, and satisfaction is as good a word as any to use for this phenomenon. The connotation is not necessarily emotional any more than in saying that a certain value of x "satisfies" an equation. It is legitimate to speak of a tree, for instance, as satisfied by maintaining its organism in the vital state and by producing fertile seeds. On the higher animal levels these biological satisfactions, although fundamentally the same, tend to become conscious and finally do acquire truly emotional value.

From this point of view, it can be said that the species prospers to (and only to) the extent that individuals attain satisfaction, and that the species is modified because some heritable characteristics assist more than others in the striving for individual satisfaction. The nature of the satisfactions operative within a given species is also heritable and subject to evolution. This appears to be quite the opposite of the view that the greatest thing individuals do for a species is to die, for death is the antithesis of individual satisfaction. Some may declare with Tennyson that nature (or evolution) does not really act this way,

> So careful of the type she seems,
> So careless of the single life.

Entomologists may insist that social insects habitually behave for

the good of the group and not for individual satisfaction, and some sociologists maintain that the sacrifice of individual satisfaction is the highest human trait and the only hope for human progress. It is, I think, a mistake to suppose either that insects do or that humans should prefer group satisfaction to individual satisfaction. The apparent anomaly is explicable by the fact that two distinct broad categories of individual satisfaction have survival value. In one case the satisfaction lies in belonging to and serving the group. It arises in the individual but as the result of an extrinsic or environmental situation.

Mutations tending to make individuals prefer extrinsic to intrinsic satisfaction have been called altruistic, for instance by Haldane, who has studied them from a neo-Darwinian genetic point of view. As Haldane has pointed out, however, what we call altruism in man frequently is not altruistic in this biological sense, nor is such biological "altruism" necessarily eugenic and its opposite dysgenic. The biological factor is not forgetfulness of self in service to others, negation of the individual, as altruism is supposed to be, but is self-satisfaction on an individual basis by means which do, as result rather than intention, tend to sacrifice the individual to the group.

Genetic emphasis on extrinsic satisfaction is unlikely to arise in large or in cross-breeding groups, and it is unlikely to have survival value for the species unless it is confined to one caste, like the neuters among social insects, while another caste, like the queens among these insects, is dominated by intrinsic satisfactions. A species in which only extrinsic factors gave individual satisfaction would be doomed to almost immediate extinction under any ordinary conditions and such a species probably could not arise. On the other hand, individuals dominated by intrinsic satisfaction, or belonging to species in the evolution of which this has the major survival value, frequently also experience extrinsic satisfactions and the conflicts and coordinations of the two give rise to some of the most elaborate forms of behavior and to some of the most complex evolutionary developments, including those of men.

In another respect the individual is a fundamental factor in the fate of genetic modifications once these have arisen. The spread of a mutation through a species (or interbreeding group), its survival or extinction, its equilibrium point, and its combination with its various allelomorphs are all functions of the number of individuals comprising the group, as has been well demonstrated by Wright, Fisher, and Haldane, among others. This aspect of the subject is somewhat aside

from the main theme of the present discussion, but in passing it is desirable to emphasize one point, familiar to geneticists but less so to paleontologists, whom it most directly concerns.

Rapid evolution and evolution involving complex new structures or fundamental reorganizations of structure depend on many factors. Some of these factors are still quite unknown, but it seems certain that the number of interbreeding individuals is one of them. It is theoretically probable and as far as observation is possible it appears to be the fact that large groups of individuals evolve relatively slowly and are less likely than smaller groups to develop any fundamental structural changes. If a paleontologist has a large number of specimens of a given group, this is usually in itself evidence that the group, when alive, was rich in individuals. Such groups do, of course, give legitimate evidence of some of the modes of evolution, but these modes may be quite different both quantitatively and qualitatively from those of groups that included fewer individuals and that are therefore rare or absent in paleontological collections. It is, then, necessary to be cautious in generalizing from such groups as the known fossil horses. It is probable that "laws of evolution" deduced from this series do not apply to the individually less abundant (and in this case still quite unknown) animals that first acquired the basic perissodactyl structures. This numerical factor may be the real reason for many of the sudden breaks and supposed leaps in the paleontological record, often explained in very different ways. It is almost surely the reason why many paleontologists have believed that evolution normally progresses with great regularity and in straight lines.

THE INDIVIDUAL AND EVOLUTIONARY FATALISM

"We are executive in ourselves—We are sufficient in the variety of ourselves."

Whatever the personal philosophy of the student, the usual approach to the practical study of evolution has been deterministic and mechanistic, or physical in a sense that has been abandoned by many physicists. In its extreme expression, as developed by some nineteenth century workers, this attitude is that if the distribution and state of all the matter and energy in the universe at a given instant were known and if all the immutable physical laws of causation were likewise known, then everything that would ever occur after that instant could theoretically be predicted. This stern creed is emotionally distasteful to most men, and it involves a number of serious logical and philosophical difficulties. It has been subject to repeated attack, and in various spheres there has been a strong reaction against it.

As far as these attacks have originated in theology, in vulgar mis-apprehension, or solely in emotionalism they do not concern us here, but in many cases they have been led by scientists and have taken the form of alternative scientific theories. In the physical sciences determinism has tended to give way to "uncertainty relations" and to a so-called statistical view of natural law. Some physicists have strayed so far from the field of the determinate and the classically mechanical that they have imagined themselves face to face with God and have set up as scientific theologians, as which they cut rather sorry figures.

In the biological sciences a somewhat similar position has been reached by different paths. Life activities are superficially so unlike most inorganic activities that it is tempting to think of life as something fundamentally nonmechanical. From this it is an easy step to the conviction that the essence of life, its real distinction from the nonliving, does not reside in any feature of physical organization but in something nonphysical or metaphysical. So the biologist reaches a conclusion suggestive of the theological distinction of body and soul, although he demands his own definition of "soul" and generally refuses to give it that name. If this distinction is valid, then there is no reason for believing that evolution and the life processes in general are mechanical sequences, and it is possible to maintain that they are modified or controlled by impalpable forces without any material basis or directly material manifestation. One eminent paleontologist has endowed these forces with some degree of personality and seriously maintains that evolution has been directed by spirits of limited intelligence and diverse intentions. This miscegenation of modern science and medieval demonology is perhaps the most extraordinary recent development of scientific philosophy, but it is an extreme, not wholly illogical, toward which much recent biological thought tends.

A related line of development of evolutionary theory has in some respects been curiously opposite to the drift of physical theory from determinism to indeterminism. A basic premise of Darwinian evolution was the existence of random variation. A more recent school of thought insists that random variations (even if heritable) have had little or no significance in evolutionary history and that evolution has followed definite predetermined and theoretically predictable lines regardless of random fluctuation. Such a descriptive theory of the course of evolution is capable of a mechanistic or even of a purely Darwinian causal explanation, but as it has been most energetically advanced (especially by Osborn) it is essentially metaphysical. When the conception of a goal is added, this metaphysical basis becomes still more evident,

and the extreme is reached with teleological judgments of the goodness or badness of mutations.

These two broad trends of thought, one maintaining that causation in evolution may be largely nonphysical and the other that evolution is a continuous, nonfluctuating sequence with a predetermined outcome, contrast in many ways but they are compatible (frequently being combined in the theoretical conclusions of a single student) and they are alike in this: that they lead to a sort of evolutionary fatalism. They reject the conclusion of Darwinism and of various other theories that the products of evolution are the results of a sequence of accidents—not accidents in the sense of things happening entirely at random but in the sense of occurrences mechanically produced by complex concatenations of circumstances, not intended and not foreordained and subject to change of direction with any change in the circumstances. In the place of this concept, the adherents of entelechy, aristogenesis, and the like maintain that evolution consists of progression toward some ideal. They feel that the products of evolution were intended, in some metaphysical sense, and they replace accident by fate.

The bearing of these philosophical considerations on the role of the individual in evolution is direct and crucial. It has been shown that under the Darwinian and the usual genetic theories, the activities and satisfactions of the individual are determining factors in the course of evolution. According to the theories of evolutionary fatalism, on the other hand, the individual does not matter unless, possibly, to himself. The direction and rate of evolution should be independent of individual factors. The transition from *Eohippus* in the Eocene to *Equus* in the Recent is considered as an orthogenetic inevitability, and all that the myriads of individuals in the sequence had to do with it was to exhibit the structures involved and to produce the succeeding generations. The same attitude toward the individual arises, *a fortiori*, in the still more metaphysical theories that assume a universal organizing force, a sort of world-soul, or spiritual guides and innovators.

As purely philosophical problems, these questions are as complex and as nearly insoluble as the question of free will, and their discussion on that basis would be as futile. As scientific theory, I find that I have here called fatalistic evolution quite untenable. Its strongest evidence has been drawn from the field with which I am most familiar and is seen in the phenomenon commonly called orthogenesis. As straight verbal description of what has happened in a few particular instances, orthogenesis and similar paleontological inferences are valid and use-

ful. As theoretical generalizations of the mode of evolution, and still more as bases for metaphysical speculation on the causes of evolution, they are not valid, or at least not in the sense of justifying fatalistic placing of the individual in the scheme of things. The lines that give evidence of orthogenesis are all individually abundant groups, regarding which necessary caution has already been enjoined. The structural changes involved are all genetically very simple in comparison with those involved in the major events of evolutionary history. They can be well explained in purely mechanistic genetic terms, with no recourse to orthogenesis in any metaphysical sense.

The individual is a pawn of fate only to the extent that his inheritance is not and his environment is only in part of his own making. These come to him as a result of past causes, not as presage of future destiny. Within this framework, so largely wrought by the actions and interactions of previous individuals in the enormous web of life, the individual makes his own fate and that of the species composed of him and his fellows.

THE INDIVIDUAL AND THE FOURTH DIMENSION

"I swear nothing is good that ignores individuals."

Among the most significant trends in zoology and paleontology are the increasing use of dynamic concepts and study of dynamic problems. The most limited and formerly the most common sort of work in these fields consisted of the examination and comparison of a supposedly representative, dead individual of any given species. The zoologist studied animals that had been dead for a few months or years and the paleontologist studied animals that had been dead for hundreds of thousands or millions of years: the technique is different, in part, but the approach is the same. Now both zoologists and paleontologists, each in the ways permitted by their materials, are more likely to study animals as functional, active organisms and not only as static morphological exhibits. This shift in emphasis has given rise to a new concept of the individual and to a new orientation of the individual in the scheme of things.

The dynamic concept of the individual is four-dimensional. An individual is not a certain combination of tissues arrested at a moment in time, but is the whole sequence of states and forms through which one animal passes from the fertilized ovum to death. That this seemingly obvious fact really represented a new viewpoint in the biological sciences is shown by the radical changes brought about by it in the recapitulation theory during the past 20 years. Although based on the
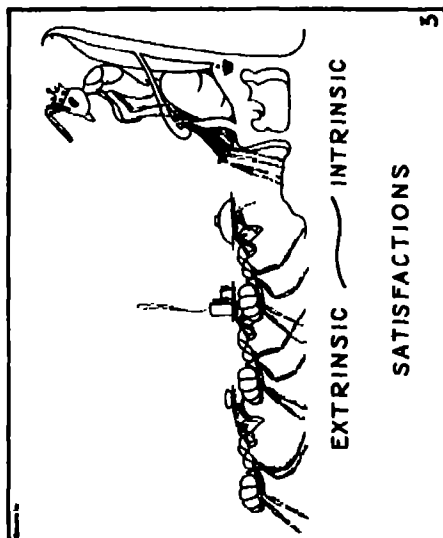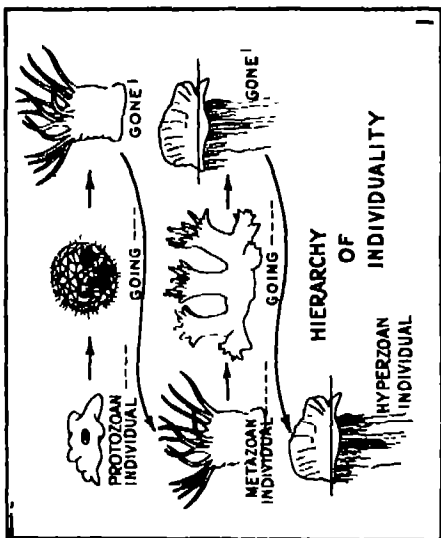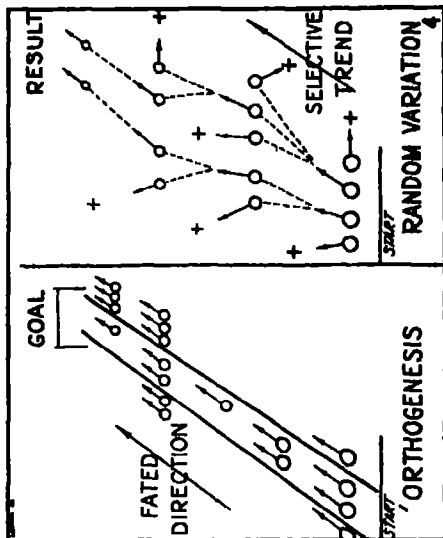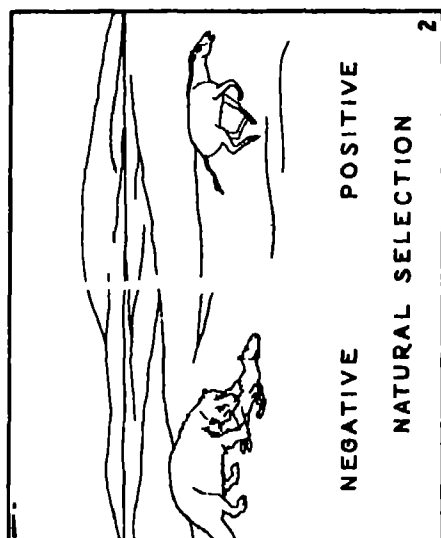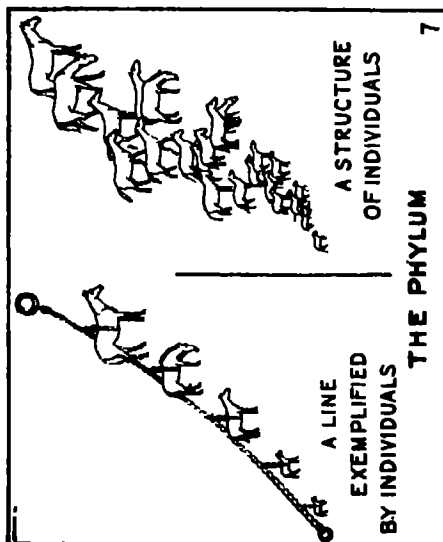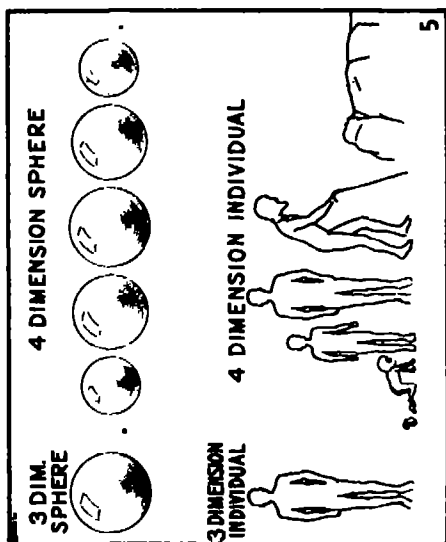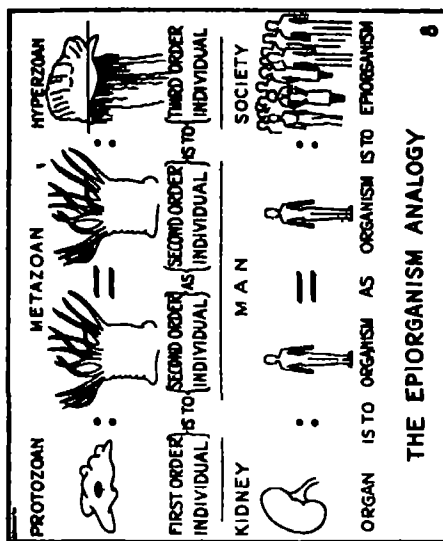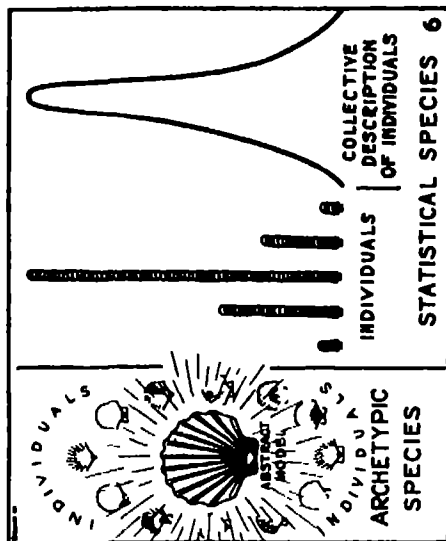
superficially dynamic idea of a succession of structural stages, Haeckel's so-called biogenetic law was fundamentally static. It really conceived of the individual as a motionless and timeless adult structure and achieved the illusion of motion (like a moving picture) by a succession of stills. Garstang has shown the true nature and limits of recapitulation in terms of a dynamic individual, inheriting not merely its adult structure but its whole life cycle from its ancestors and showing modifications in every part of that cycle effected by the same sort of hereditary and evolutionary factors as those influencing the final, static form. .

Analogous dynamic concepts have been applied in the consideration of groups and of the relationships of individuals to groups. The philosophical zoologists of the late eighteenth and early nineteenth centuries, such as Goethe, Oken, and Owen, developed the theory of archetypes as ordained patterns more or less closely followed by individuals. As a thousand freehand sketches from the same model would vary, so do individuals vary from the archetype, but the variations have no significance for the study of the essential, the philosophical reality, which is the model and not the individual sketch of it.

The spread of evolutionary zoology led to the abandonment of the philosophical concept of archetypes, but the static point of view involved in it was not immediately discarded and indeed persists to considerable degree today. The diagnosis of taxonomic groups by statement of a combination of fixed characters believed to be common to all members of the group is almost exactly the same process as the delineation of an archetype, however different in intention and interpretation. It relegates the individual to the same insignificant role, attempting, not the simultaneous description of a group of individuals, but the abstraction from them of all that is not individual.

A newer and, I think, incomparably truer and more profitable point of view is making rapid headway although still far from universal recognition. This is that the group is best definable as a collection of individuals and not as an abstraction of the nonindividual. This does not mean that the group is to be defined on the basis of one or a few individuals, a fault rather of the old, static, pseudo-archetypal taxonomy than of the new, dynamic, statistical taxonomy. On the contrary, full definition in the newer sense requires the examination and use of more individuals. If only one is available, the group definition or concept derived from it must be more loosely drawn; the unique specimen is not an example of an archetype but one of a collectivity of individuals

and due allowance must be made for the probable varying character-
istics of the unknown individuals of the group.

According to this concept, the differences between individuals are as
much characters of the group as are their resemblances and may be
more important from an evolutionary point of view. The "characters
in common" of static group concepts are replaced by determinations
of central tendency and importantly supplemented by the study of
dispersion. These concepts are essentially statistical, although it
would be dangerous to give them that name before an audience inade-
quately acquainted with them. Some zoologists still think of statistics
as a rather mysterious and very complicated mathematical game
played with long lists of measurements. Statistical concepts, as the
term is used here, involve a point of view that may be quite as perti-
nent to one observation as to a thousand and to a purely qualitative
character as to a measurement.

It may be said that the statistical procedure is to describe the group
as such rather than in terms of the individual, and it is superficially
paradoxical to say that this restores the individual to the basic and es-
sential position denied it in the older group concept, which often was
expressed in terms of the individual. The paradox is, however, easily
resolved. The statistical group concept seeks to take into account all
the characteristics of all the individuals of the group, while reducing
their description to collective terms. The archetypal group concept
seeks to eliminate all characteristics by which individuals are distin-
guished, even though it may describe the residuum in individual terms.

Especially in the hands of paleontologists (although not yet by all
of them), group concepts are also coming to have a fourth dimension
analogous to the four-dimensional concept of the individual. To non-
evolutionary zoologists, the archetype was divinely ordained and im-
mutable except by subsequent divine renovation. The archetype-like
group definitions of evolutionary zoologists had, of course, to be muta-
ble, but the expression of phylogeny was really a succession of static
pictures, like the Haeckelian concept of ontogeny. A phylum in time
was recognized and defined primarily in terms of the common char-
acters of all its species, just as the species was discussed in terms of the
common characters of its individuals. But the particular sorts of
groups to which the name phylum may be applied in a general sense
include a time dimension. The secular changes that occur in them are
as essential and characteristic as are their common or immutable
features, and from an evolutionary point of view considerably more

important. Thus the concept of a phylum (or of any taxonomic group with perceptible extension in time) becomes dynamic, and it is better defined in terms of the changes that occur within it than in terms of its constant differences from other groups.

For the present subject the most important conclusion from this dynamic approach to taxonomy and phylogeny is corroboration and extension of the conclusions already drawn from evolutionary theory. The group is not an entity in the sense that the individual is an entity. A group achieves adaptation and progresses only in the sense that the individuals composing it do so. Satisfaction is an individual compulsion and not a group achievement. Evolution is not a thread on which individuals are strung, but a structure composed of individuals. A species is not a model to which individuals are referred as more or less perfect reproductions, but a defined field of varying individuals. A phylum is not a supermodel that abstracts the immutable features of a group of specific models, but a flowing river of ever-changing individuals.

THE INDIVIDUAL AND TOTALITARIANISM

"The only government is that which makes a minute of individuals"

"There arises a four-dimensional picture of the totality of life, with time as the fourth dimension, just as the individual gradually develops by growth from one cell all the organs that finally compose the complete body. The organs do not arise at random, but in the frame of the whole and some also degenerate before the whole body reaches maturity. In the development of the individual which in turn is only a subordinate part of the totality, an item is dominated by the unity of the whole, and in the same way the general evolution of life also exhibits a higher level of organization, an organic course of life."

"And now a final word about the future of society, the further evolution of the epiorganism. Unless the consistent indications of a great range of biological knowledge are all erroneous, the epiorganism will move toward increasing integration. . . . Units will become more specialized and interdependent, present epiorgans will improve in function and new ones will appear. The individual will be more and more a part of the whole state, though it will remain meaningless to ask the question, 'Does the citizen exist for the state or the state for the citizen,' since reciprocal influence is the essence of an org."

These passages were published at about the same time, in 1940, the first by a great German paleontologist, F. von Huene, and the second by a great American physiologist, R. W. Gerard. Both men, like others

before them, are comparing the individual within his society or group
and an organ within the individual. Converging on this end from dif-
ferent directions, both reach the conclusion that the individual is part
of a higher organism in the same sense that a cell or an organ is part
of an individual. Both at least imply the proposition that the welfare
of the higher organism, the epiorganism of Gerard, is of paramount
importance in evolution and that the individual is to be viewed pri-
marily as a subordinate unit. As far as his scientific work shows, the
German quoted is as nonpolitical as one can be in Nazi Germany, and
the American is outspokenly anti-Nazi, but the conclusions of both
are sound totalitarian ideology. The question arises whether these
conclusions are also sound biology, and in the world today considera-
tion of the role of the individual in evolution can have no greater hu-
man value than by answering this question.

The transfer of knowledge and of judgment from one field to an-
other is notoriously difficult, and one need not look far to find men
eminent in one field who have made themselves ridiculous by posing as
oracles in another. The biologist as sociologist, still more as political
prophet or propagandist, runs a similar risk, but we are all necessarily
concerned with social evolution. Whether or not they are really per-
tinent, biological theories are being used in this field, and the biologist
necessarily has a part in the discussion, if only as critic.

The physical sciences have been accused of providing the material
resources of war and oppression and their students have lately been on
the defensive and most vociferous in endeavors to prove the accusa-
tion unjust. Now the biological sciences are being used to provide the
more insidious and still more menacing moral implementation of to-
talitarianism. If this use is wrong, scientifically, and if free biologists
support it or even tacitly permit it, then they will deserve an accusa-
tion stronger than any that can be brought against physical science
and they will be contributing to their own destruction.

The analogy between the individual and society, or between organ-
ism and epiorganism (an *a posteriori* terminology that assumes the
full validity of the analogy), is very old. Everyone has heard it, and
most of us have used it as a figure of speech. When it ceases to be a
figure of speech and becomes a basis for advice and action, it enters a
new and more dangerous sphere and becomes subject to more critical
examination and limitation. In this extended form the reasoning runs
as follows: Cells and organs compose an individual. Individuals com-
pose a society. The functional relationships of part to whole are analo-
gous in the two cases. The evolutionary principles involved in the

integration of cells and organs into complicated individuals of increasingly higher type can and should be transferred to the political field as guides for the evolution of increasingly complex and higher types of society.   •   .

The biologist who accepts this argument soon finds that he is envisioning, perhaps even recommending, a society in which the individual is a specialized organ in a superindividual organism, in which, indeed, he is not an individual in the usual sense. The evolutionary analogy suggests to him that the epiorganism will and should evolve in the direction of greater integration (i.e., less individual freedom and responsibility), and that its units (i.e., you and I) should become more specialized (with less scope for activity and change), more interdependent (less self-reliant), and more a part of the whole state (less individual). (These conclusions, exept for the parenthetical expressions, are paraphrased from Gerard). Then the biologist finds himself face to face with the fact that this is the totalitarian ideal. Of course, the politically totalitarian biologists accept the conclusion gladly and are strengthened and comforted by it. If, however, a biologist happens not to be politically totalitarian, he is likely to be shocked and to look for a way of avoiding his own conclusion.

The most obvious escape from this dilemma is to decide that totalitarianism is good or "basically progressive," as Gerard says, but that Nazism, for instance, is bad totalitarianism. The point is important enough to warrant brief examination of the more essential arguments given by Gerard and others.

Democracies are said also to be progressing toward integration, but aside from this general direction to be doing so in a biologically eugenic way while the existing totalitarian states are advancing in a dysgenic direction. That democracies are advancing toward integration in a totalitarian sense, except as they may be moving toward actual totalitarianism (for better or for worse), is open to question. Even supposing it true, their integration is different both in degree and in kind from an epiorganic structure. It is not at all in the direction of what I have called hyperzoan individuality and it is not totalitarian according to current ideologies.

The wrongness of direction of the existing totalitarian states is said to be shown by overspecialization, by isolation, by reversion to rule of force, and by deliberate excision of episense organs. That the direction is wrong I most heartily agree, but these arguments are so easily refuted, if their analogical basis be granted, that they can only comfort the nations that they are meant to confound. Gerard gives the saber-

tooth tiger and the king-crab as analogies for overspecialization and as evidence that the Nazi epiorganism is doomed to extinction. The sabertooth specialization was, in fact, one of the most successful ever developed by a mammal. The machairodonts maintained their high level of specialization for conflict over a period of at least 30,000,000 years. True, they are extinct now, but the most probable reason for their ultimate extinction was the extinction of their accustomed prey. The analogy certainly does not favor the democracies! The king-crab is a worse example. This group has survived almost unchanged since the Triassic and is thriving now. Far from dooming it to extinction, its specializations seem almost to be a recipe for group immortality. But the example really has nothing to do with the case, because the totalitarian nations unfortunately are not withdrawing into a figurative shell.

As regards isolation, the argument seems to be going off at a tangent, because this does not really involve the organism-epiorganism analogy on which the rest of these conclusions are based. Moreover, it is not the totalitarian nations that are tending toward isolation in an evolutionary sense. Quite the contrary. They are the exponents and the present practitioners of expansion, migration, conquest of hostile environments, and competition with other epiorganisms—the very sort of activities that have produced the most potent and successful organisms in biological evolution. It is our own democratic country that shows a tendency toward isolation, the biological analogue of which has dysgenic results.

The integration of an organism is necessarily one of compulsion. What higher organism could function if a muscle reacted by its own free consent? Integration is only achieved by the fact that a muscle must react when told to and can have no choice in the matter. If society should be integrated in these organic terms, it is therefore meaningless to say that rule by force is bad. On these premises, it is not only inevitable and necessary but also biologically good. A truly integrated epiorganism can only function by force.

By the excision of episense organs, Gerard means ideological limitation and official control of scientific and other intellectual activities. But from the totalitarian point of view there is no excision in this but only integration. The totalitarians can and do use the same analogy to demonstrate that they are not gouging out the eyes but are only making them focus and direct themselves in accordance with the will and needs of the whole organism. In an integrated organism there can not be any individual freedom of the parts. Only a diseased eye looks

where it will rather than where it is told to look. So in a perfect to-
talitarian epiorganism there should be neither freedom of action nor
of thought, except in the unique leader, for these are symptoms of epi-
organic disease. The biologist may conclude that he and his fellows
should be the directive organs of the epiorganism and that the lesser
breeds then do not need any freedom of thought or action, but experi-
ence shows that an epiorganism is more likely to differentiate its
brains from housepainter-tissue than from scientist-tissue, and there
is no evidence that the results would be very different in either case.

If totalitarianism is good, in itself, I see no escape from the conclu-
sion that the present totalitarian states of Europe are fundamentally
good and are on the best course of human evolution, whatever mis-
takes they may make on the way. (Democracies are not characterized
by inability to make mistakes.) The organism-epiorganism analogy
does logically and inevitably commend basic structures and principles
of the states, whether Nazi, communist, fascist, or shinto, that accept
totalitarian theories or practices. The democratic biologist who adopts
this analogy in all its extension has no valid escape from the dilemma
and no logical choice but to shift his allegiance.

The other alternative is to recognize that this use of the analogy is
completely unsound. The relationship of the individual to society is
fundamentally unlike that of the organ to the individual. The two re-
lationships involve entirely different orders of things and do not be-
long in the same field of thought. As well say that electrons and their
fellow particles compose silver, that silver analogously composes a
photographic image, and then criticize the photograph because its
pictorial composition is unlike the organization of a silver molecule.
It is obvious that an individual is not an organ of society in the sense
that a liver is an organ of an individual, but the very boldness of the
metaphor and its wide applicability have made intelligent men forget
that it is only a metaphor.

Such analogies are valid only as far as the two terms are well known
and their analogical relationship is a matter of observation. Thus far
they have descriptive value, but they warrant no extension to infer-
ences beyond the field of observation. They have no predictive value
and they do not permit transfer of knowledge and principles from one
field to another. The biologist who elevates the organism-epiorganism
metaphor into a standard for social interpretation and recommenda-
tion is guilty of the most reckless, unjustified, and nonscientific extra-
polation.

A hyperzoan individuality, such as was mentioned in the introduc-

tory remarks, does not and can not possibly exist among mankind. A social group has no individuality according to the biological concept of the individual, and the extension to it of the same term is more likely to be confusing than enlightening. While exploring the analogy at least to, and I think somewhat beyond, the full extent of its validity, Julian Huxley has noted this essential limitation. "But," he wrote in the same journal as Gerard (Scientific Monthly) and in the same year (1940), "whereas the individuality of the body of a higher animal, cuttlefish, insect or vertebrate is far more developed than that of its constituent cells, that of a human society is far less so than that of its individual units. This fact, while it makes the analogy between cell and human individual almost worthless, is of great value itself as a biological analogy, since it immediately exposes the fallacy of all social theories, like those of Fascism and National Socialism, which exalt the state above the individual."

There is a true biological-sociological analogy, in part a true homology, and that is between the relationship of the individual to the evolution of species and to the evolution of social groups. I have failed in my purpose if the bearing of this analogy on the present state of human affairs is not now becoming clear. The group is a collectivity of individuals. It has no entity except as derived from the relationships of individuals. It does not evolve except as individuals change. It does not prosper except as individuals prosper, and it is incapable of satisfaction but is modified and perpetuated by individual desires and attainments of satisfactions.

The integration that has been progressive in evolution, that has led to higher types of life and that has been "good" biologically, or eugenic, has been integration of the individual. The ability of the individual to function freely, and in increasingly complex and varied ways has had survival value and has been progressive. Development of individual dependence and loss of individual versatility have usually been degenerative. In the line leading to man, the ability to form and to manage complex social structures has certainly followed the development of ever greater individual capacities and adaptability and, socially, a growing awareness of the rights of other individuals, which is the opposite of social subordination of individuals.

In this evolution it is clear that intrinsic satisfactions, as I have defined them on a previous page, have been dominant although extrinsic satisfactions have also played an important part. In addition to the profound error of supposing satisfaction to affect groups in a way different from the sum of the satisfactions of the individuals compos-

ing the groups, it is a characteristic of the totalitarian nations to emphasize extrinsic individual satisfactions at the expense of intrinsic. This is opposite to the emphasis that led to human evolution, physical and social, and if successful it seems biologically probable that it would lead not to a continuation of evolution to higher human levels but to a change of direction from human to nonhuman. The end of that different direction is exemplified for us by the social insects. I doubt whether even the most rabid myrmecophiles really want to live in a society patterned along those lines. In fact, it seems biologically impossible that the experiment can succeed, simply because we are mammals and were evolved as we were. We have neither the inheritance nor the genetic potentiality for making extrinsic satisfactions superior to intrinsic in survival value.

Biological justification for the totalitarian development of society has also been sought in the doctrines of evolutionary fatalism. Regardless of such labels as "right," "wrong," "good," or "bad," it is argued, this is the inevitable future. Mankind is going this way just as horsekind was going toward *Equus* throughout the Tertiary. Opposition is as futile and foolish as if the little *Eohippus* had said, "I am going to be a dinosaur," instead of "—a horse."

Even aside from the fact that this is another false use of analogy, it has been shown that a fatalistic view of evolution has little scientific support. It is not a probable hypothesis, still less a necessary one. A poet like Mrs. Lindbergh may urge submission to "the wave of the future," but a scientist may still believe that we are making our own future and that we have the capacity to make it to our liking and for the good of all of us as individuals.

The essence of democracy is belief in the importance and independence of the individual, and in the progress of society through the satisfactions of the individuals composing it. The essence of totalitarianism is belief in the unimportance of the individual and his subordination to the state, and in the progress of society as a thing in itself regardless of the satisfactions of the individuals in it. I believe with all my heart and head that the democratic principles are biologically sound and humanly eugenic, the totalitarian principles unsound and dysgenic. I believe that it is our duty, not as citizens of a democracy but as among the dwindling number of citizens of the world still privileged to live and think as individuals, to oppose the totalitarian fallacy and to maintain the true place of the individual in our social and in our biological philosophy.

PALEONTOLOGY.—*Ostracoda from the Devonian (Onondaga) chert of west Tennessee.*[1]   R. S. BASSLER, U. S. National Museum.

In the vicinity of Camden, Benton County, Tenn., along the line of the N. C. & St. L. Railroad, are large quarries exposing the Devonian formation that J. M. Safford and Charles Schuchert in 1899[2] described as the Camden chert of Lower Oriskany age, judging from the macrofossils. Then, as outlined in Miss Wilmarth's *Lexicon of Geologic Names of the United States,*[3] Professor Dunbar in 1918[4] restricted the term Camden chert to the upper 200 feet of the original formation, which he determined as of Onondaga age, and subdivided the lower part into the Harriman chert (0–55 feet thick) underlain by the Quall limestone (0–10 feet thick), both of Oriskany age, and at the base, the Decaturville chert (0–6 feet thick) of Helderbergian age. The ostracod fauna here described from the true Camden chert is of special interest for the beauty of the specimens and the unusual way in which they have been preserved. Only the strongly marked species are here described; the smooth forms remain for some future work.

The cherty beds of the Camden as well as most other chert formations were originally limestones that during long weathering had been replaced by silica. In the resulting cherts the fossils are usually represented by molds or by an internal cast separated by a space from the wall of the mold. The porous cherts of the Camden formation afford excellent gutta-percha squeezes not only of the larger fossils but also of such microscopic ones, as the Ostracoda. In addition, quite perfect free silicified Ostracoda may be found by washing the white clays resulting from the final decomposition of these cherts. Such specimens reproduce the original ostracod shells with exact fidelity, although they are in reality siliceous pseudomorphs formed as a result of several replacements. First, the original calcareo-chitinous shells are replaced by lime; next by silica, when the enclosing limestone is changed to chert; then the silicified fossils are leached out leaving molds that later are filled by another infiltration of a different form of silica; and finally, the silicified limestone is reduced by weathering to a white clay, a form of tripoli, leaving the fossils, now siliceous pseudomorphs for the second time, unchanged.

More study is necessary upon the various Early Devonian ostracod

faunas, but the present assemblage seems to be related to that from the Lower Oriskany Shriver chert of Maryland and Pennsylvania and the Onondaga of the same States. A small sample of the Clear Creek chert from the vicinity of Jonesboro, Ill., shows good casts of many of the species herein described from west Tennessee, so that there appears to be no doubt of the equivalence of these two formations.

The following descriptions have been much abbreviated not only to save space but also because the author believes that the long discussions of Paleozoic Ostracoda so often printed are more confusing than helpful and that an accurate photographic figure clearly showing the characters combined with a few remarks as to the specific features is sufficient for most purposes. All the specimens illustrated on the plate are from clay beds resulting from the decomposition of chert layers near base of the Camden formation at the quarry half a mile south of Camden, Tenn. Collections at this point were made by Professor Schuchert for the National Museum many years ago, then by the writer later, and finally in more abundance by Dr. G. A. Cooper and R. D. Mesler in recent years. The types are the property of the U. S. National Museum. Measurements are omitted throughout this article because they can be easily determined from the illustrations.

DESCRIPTIONS OF GENERA AND SPECIES

Paraparchites mesleri n. sp. (Leperditellidae Ulrich and Bassler)   Fig. 1

Carapace similar to *P. subrotunda* Ulrich from the Onondaga (Jeffersonville) limestone of the Falls of the Ohio, but differing in that the ends of the valves are almost equally rounded. The specimen figured by Kindle in 1912 from the Onondaga of Little Moccasin Gap, W. Va., as *Leperditia subrotunda* Ulrich, has the ends similarly rounded and in spite of its imperfect preservation should probably be referred to this new species.

Halliella pulchra n. sp. (Primitiidae Ulrich and Bassler)   Fig. 2

Although related to the genotype *H. retifera* Ulrich from the Onondaga (Jeffersonville) limestone at the Falls of the Ohio, this beautiful new species may be distinguished by its equally ended, more evenly elevated, coarsely reticulated valves, with a thin crestlike border around the free edges and a slightly curved carina above the hinge line. A faint median sulcus terminates in a small, deep, almost central pit.

Parabolbina loculosa n. sp. (Hollinidae Swartz)   Fig. 3

Similar to *P. limbatus* Swartz, 1932, from the Oriskany (Shriver) chert of Pennsylvania, but differing in the more prominent well-rounded node on each side of the dorsal median sulcus, in the long narrow anterior spine, and the frill along the posterior half of the ventral margin composed of four folds forming well-marked loculi.

Ctenoloculina n. gen. (Tetradellidae Swartz)

Tetradella-like shells with valves crossed transversely by four flat-topped,

finely reticulated ridges separated by narrow furrows and with the free margins surrounded by a false border, which in the female is swollen to form 4 to 6 loculi or brood chambers. Right valve grooved on free margin to receive edge of the left.

Genotype.—Tetradella cicatricosa Warthin, 1934. Hamilton of Michigan, Ontario, etc.

Ctenoloculina cristata n. sp.   Fig. 4

In this new species the four reticulated ridges are not as regularly arranged as in the genotype, the posterior one being crossed by a furrow dividing it into two; the next one being irregularly triangular in outline; and the third and fourth, the two anterior ones, being separated only by a sharp crestlike line. This crest is joined by one bounding the anterior ridge and proceeds posteriorly along the free margin above the true edge of the valve. In the female form three loculi are found in the posterior half between this crest and the true margin.

Bollia ungulata n. sp. (Drepanellidae Swartz)   Fig. 5

Like *B. ungula* Jones but differing in the shorter, higher valves with a more pronounced bulb occupying the anterior limb of the inner ridge

Bollia tribolbina n sp   Figs. 6, 7

Characterized by its small, elongate carapace with narrow uniformly developed outer ridge closely following the entire free margin, and a sharply angulated inner ridge composed of a bulbous anterior part and narrower ventral and posterior portions, each ending in a slight expansion

Bollia obesoides n. sp.   Figs 8, 9

Similar to *B. obesa* Ulrich from the Onondaga (Jeffersonville) limestone of the Falls of the Ohio, but differing in the more developed and rounded marginal ridge and the minute spines along both ridges but particularly along the ventral edge.

Bollia burgeneri Swartz, 1932   Fig 10

This species, which is quite similar to *B sagittaformis* Swartz, 1932, differs in that the posterior limb of the inner ridge is quite enlarged to form a somewhat rounded, flattened knob The Tennessee specimens vary from the typical Shriver chert Pennsylvania form in the greater thickness of the posterior limb, a character apparently not of varietal importance

Bollia sagittaformis Swartz, 1932   Fig. 11

The large size, the well-rounded and uniformly developed outer ridge, the equally obtuse cardinal angles, the U-shaped inner ridge with triangular harpoon-like knob forming the anterior portion, and the narrow posterior limb, characterize this fine species, which is one of the commonest ostracods in this fauna.

Ulrichia crassimuralis n. sp. (Drepanellidae Swartz)   Fig. 12

Although much like the genotype *U. conradi* Jones, from the Hamilton at Thedford, Ontario, in outline, minute punctation, and arrangement of the nodes, this species is readily distinguished by its well-developed, more pronounced marginal ridge.

Aechmina longior n. sp. (Aechminidae Swartz)   Fig. 13

Very similar to *A. cuspidata* Jones from the Wenlock of England, but the dorsal spine is relatively longer and narrower and the free edges of the valves are furnished with very delicate spicules.   •

Aechmina equilateralis n sp   Fig. 14

Although quite similar to several species of this genus, this one is distinguished by the short blunt spine arising from about the middle of the upper edge of the valve which in addition is equal ended and bears minute spines along its ventral edge

Amphissites ulrichi n. sp. (Kirkbyidae Ulrich and Bassler)   Fig. 15

Although obviously related to *A. subquadrata* Ulrich of the Onondaga (Jeffersonville) limestone at the Falls of the Ohio, etc., the marginal free edge in this new species is distinctly raised but the coarse reticulation continues to the border of the valve. Moreover, the dorsal angles are more obtuse and equal, the carapace is larger, and the surface markings are coarser.

### Amphissites lunatus n. sp   Fig 16

This beautiful species is readily recognized by the broad, crescentic, elevated band crossing the carapace parallel but at some distance from the ventral edge, covered with scalelike reticulations A well-developed central pit occurs just above this band, and the entire surface in general is marked by finely reticulate ornamentation Rising just above the free margins of the valve is a sharp linear crest

Thlipsura furcoides n sp (Thlipsuridae Jones)   Figs. 17, 18

This fine, abundant species differs from *T furca* Roth of the Helderbergian

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Illustrations ×20 of Camden chert (Onondaga) Ostracoda from Camden, Tenn. The catalog numbers are those of the U S National Museum

Fig. 1 —*Paraparchites mesleri* n sp (holotype, right valve probably, No 101021) Fig 2 —*Halliella pulchra* n sp (holotype, right valve, No. 101022). Fig 3.—*Parabolbina loculosa* n. sp. (holotype, imperfect left valve, No 101023). Fig. 4 —*Ctenoloculina cristata* n gen and sp (holotype, male, right valve, No 101024) Fig 5 —*Bollia ungulata* n sp. (holotype, right valve, No 101025). Figs 6, 7 —*Bollia tribolbina* n sp (cotypes, right and left valves, No 101026) Figs 8, 9 —*Bollia obesoides* n sp (cotypes, two left valves, No 101027) Fig 10 —*Bollia burgeneri* Swartz, 1932 (plesiotype, right valve, No. 101028) Fig 11 —*Bollia sagittaformis* Swartz, 1932 (plesiotype, left valve, No 101029) Fig 12 —*Ulrichia crassimuralis* n sp (holotype, right valve, No 101030) Fig 13 —*Aechmina longior* n sp (holotype, left valve, No 101031). Fig 14 —*Aechmina equilateralis* n sp (holotype, right valve, No 101032) Fig 15 —*Amphissites ulrichi* n sp (holotype, right valve, No 101033) Fig 16 —*Amphissites lunatus* n sp (holotype, right valve, No 101034) Figs 17, 18.—*Thlipsura furcoides* n sp (cotypes, left valves of a mature and a young specimen, No 101035). Fig 19 —*Thlipsurella laevis* n sp (holotype, left valve, No. 101036) Fig 20.—*Thlipsurella cooperi* n sp (holotype, right valve, No 101037) Figs 21 22 *Thlipsurella secodefta* Swartz, 1932 (plesiotypes, two right valves, No 101038) Figs 23, 24 —*Thlipsurina elongata* n gen and sp (cotypes, right and left valves, No 101039). Fig 25 —*Thlipsurina simplex* n sp. (holotype, right valve, No 101040). Fig 26.—*Thlipsurina similis* n sp (holotype, right valve, No 101041) Figs 27, 28 —*Ranapellis typicalis* n gen and sp (cotypes, right valves of a mature and a young specimen, No 101042) Fig 29 —*Ranapellis unicarinata* n sp. (holotype, left valve, No. 101043) Figs 30, 31.—*Octonariella clavatula* n. sp (cotypes, left valves, No. 101044). Figs. 32, 33 —*Octonariella bifurcata* n sp (cotypes, right valves, No 101045) Figs. 34, 35 —*Octonariella bispinosa* n. sp (cotypes, left valves, the latter slightly broken, No. 101046) Figs 36, 37 —*Octonariella typica* n gen. and sp (cotypes, left and right valves, No 101047).
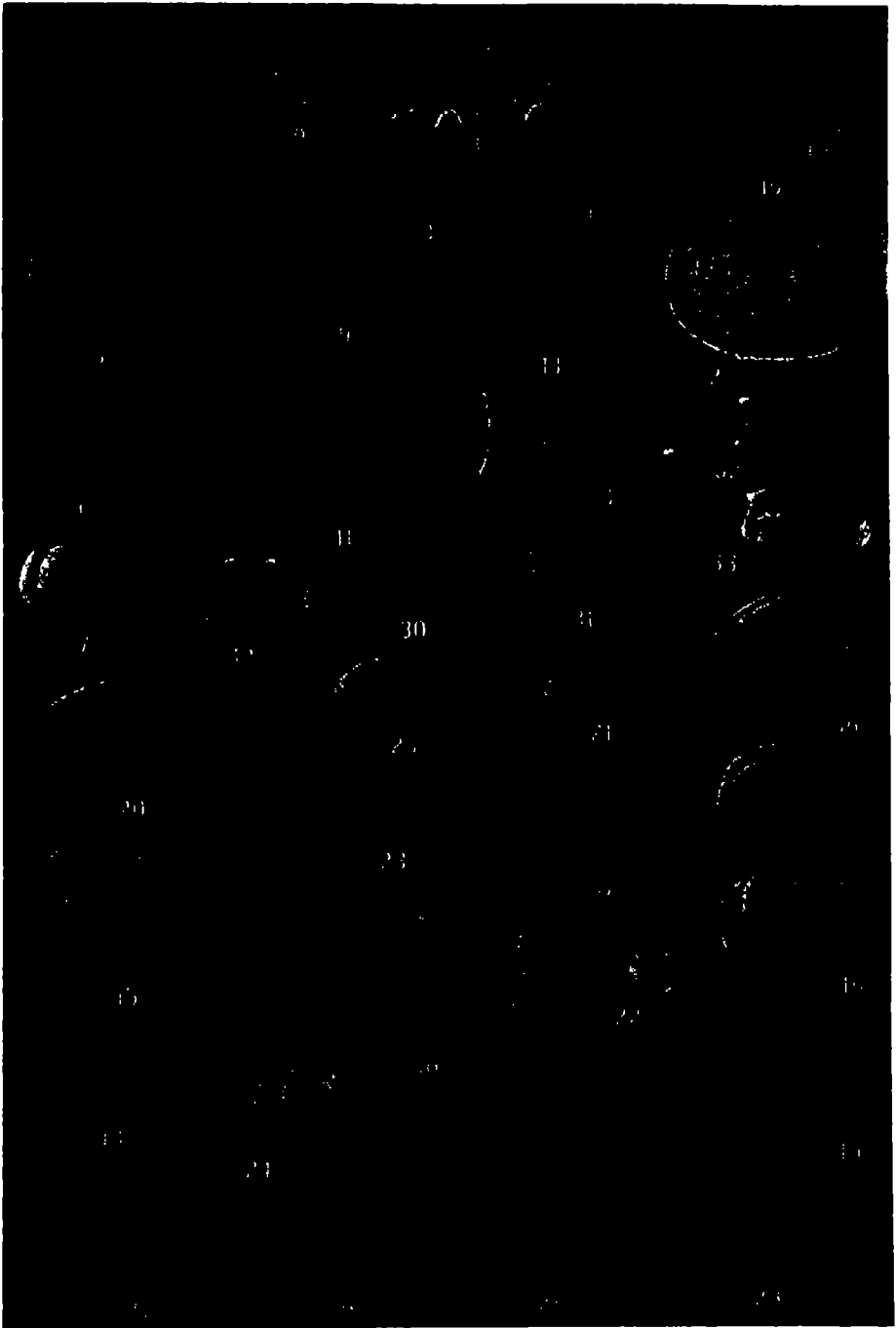
Figs 1-37 —(See opposite page for explanation.)

(Haragan marl) of Oklahoma in its more robust elongate carapace, flatter valves, its shorter and more bulbous median ridge, and its sharper, more projecting ventral protuberance.

Thlipsurella laevis n. sp. (Thlipsuridae Jones)   Fig. 19

Valves reniform in outline with narrow posterior end. Surface gently rounded with a flat margin along dorsal two-thirds of anterior end bounded by a sharply elevated, narrow, diagonally direct ridge behind which is a broad furrow irregularly triangular in outline extending to the middle of the valve along the midlength. Right and left valves with similar surface markings.

Thlipsurella cooperi n sp.   Fig. 20

Valves elongate oval, with gently rounded surface marked at the posterior end by a slightly curved sulcus and at the anterior end by a flattened margin along the dorsal two-thirds bounded by a curved ridge, which in turn is succeeded by a narrow, somewhat triangular furrow.

Thlipsurella secoclefta Swartz, 1932   Figs 21, 22

The Tennessee specimens here figured agree with the Pennsylvania Shriver chert types in all respects except that the submedian cleft is better developed and the two pits behind it are often united

Thlipsurina n gen. (Thlipsuridae Jones)

Similar to *Thlipsura* in general shell characters but differing in the absence of a posterior sulcus and in the presence of a broad, shallow, transverse, median depression and of a flattened anterior end bounded by a sharp ridge which in turn is followed typically by a broad, deep, curved sulcus expanding in width from the hinge line to the ventral margin. Surface markings alike on both valves
Genotype.—*T elongata* new species.

Thlipsurina elongata n sp   Figs. 23, 24

The elongate carapace, the flattened anterior marginal area succeeded posteriorly by a well-developed sulcus increasing in width toward the ventral edge, and the broad median transverse shallow depression, characterize this new species

Thlipsurina simplex n sp   Fig 25

Similar to *T. (Thlipsura) primitiva* (Roth) from the Helderbergian (Haragan) of Oklahoma, but differing in the oval instead of wedge shape of the valves and the narrow, flattened anterior border.

Thlipsurina similis n. sp   Fig. 26

Similar to the genotype but differing in the less elongate, higher carapace with the central depression better developed. Both sides of the carapace are known and are similar to each other.

Ranapeltis n gen. (Thlipsuridae Jones)

Hinge, without overlap, but right valve seems slightly to overlap left along the ventral margin. Valves subtrapezoidal to subreniform marked in the type species by two narrow ridges developed parallel to the ventral margin and turning upward at an acute angle towards the dorsal edge and in the second species by only a single ridge. A large eye spot or muscle scar is centrally located within the inner ridge and the free edge of valves bears a spine at the angular anterior end.

Genotype.—R. typicalis new species.

Ranapeltis typicalis n. sp.   Figs 27, 28

The two parallel ridges bent abruptly toward the dorsal but reaching only about half the distance, the muscle spot, and the angular anterior ventral margin with its pointed spine, are characters that make this ostracod easy to identify.

Ranapeltis unicarinata n. sp.   Fig. 29

Although similar in general features to the genotype, this species has but a single ventral ridge, which, however, in turning toward the dorsal margin bends abruptly toward the center, each end terminating in a decided bulb, with the strongly marked muscle impression midway between them The anteroventral spine is as well marked as in the type species.

Octonariella n. gen. (Thlipsuridae Jones)

Inequivalved shells with the larger left valve overlapping the right on the free edges, the surface pattern of opposite valves sometimes different and the typical U-shaped annular ridge of *Octonaria* replaced by a single ridge in the anterior half and a bifurcated ridge posteriorly, the latter terminating in two prominent spines one at each end of a sharp transverse connecting bar. Spaces between ridges marked by a series of pitlike depressions.

Genotype.—O. typica new species.

Octonariella clavatula n sp.   Figs. 30, 31

Anterior and posterior ridges so joined that valve appears traversed lengthwise by three parallel elevations, the outer two united at the anterior end and terminating in a bar with spines at the posterior Two rows of pits developed between the three elevated areas. Although related to *O. (Octonaria) clavigera* (Ulrich) of the Onondaga at the Falls of the Ohio, the central ridge in the present species does not stand out like a club

Octonariella bifurcata n sp.   Figs. 32, 33

This well-marked ostracod may be recognized by its narrow elongate form and very prominent posterior spines. In the distribution of the ridges and depressions it resembles *O bispinosa* a broader species of which it might be considered the opposite valve. This is not the case, however, since both right and left valves with the characters here figured are known.

Octonariella bispinosa n sp.   Figs. 34, 35

Both valves of this common species are known and differ little from each other. The characteristic features are the shorter, higher form of the valve and the consequent increase in the number of depressions between the ridges, which as usual end in two well-marked spines.

Octonariella typica n. sp.   Figs. 36, 37

This very abundant ostracod is represented by both valves and complete examples leaving no doubt that the two somewhat different aspects figured represent the same species. The smaller (right valve lacking the broad overlapping border of the left bears a row of large coarse pits next to the anterior free margin and two rows of two and of three pits, respectively, parallel to · the ventral margin. The latter rows are joined by a crest at each end of which is a small sharp spine. The larger overlapping valve has the same general arrangement of pits but broad posterior and anterior borders distinguish it.

PALEOBOTANY.—*Notes on the Pleistocene of Maryland.*[1] ED-
WARD W. BERRY, Johns Hopkins University.

The idea that the Pleistocene deposits south of the terminal moraine
were due to changes in relative level of land and water and were to be
interpreted by their topographic height and form we owe to Shattuck,
who, after setting forth his hypothesis in several earlier papers, gave
it its final form in 1906 in the volume discussing the Pliocene and
Pleistocene deposits of Maryland. Shattuck was a brilliant worker,
but not a sustained and persevering detailist. Having published his
interpretation he apparently lost interest in it and never during the
rest of his life returned to the subject. It was, however, adopted by a
number of younger men and extended throughout the remainder of
the Atlantic and Gulf Coastal Plain. There have always been physiog-
raphers who have been violently critical, although on the whole I
think it is fair to say that Shattuck's interpretation, with, of course,
modifications of detail, has been generally accepted by geologists. One
of the difficulties for many minds has been the problem of visualizing
a complex series of events in terms of a rather rigid scheme of changes
of level, or of differentiating the episodes in an actual exposure from
the final event that controlled the surviving topographic form. There
was, too, the difficulty in many minds of visualizing the marine con-
trol, which changes of level exercised in stream valleys even though
the sediments were not actually marine and did not contain marine
fossils. The time involved is inconsiderable as geologic time is reck-
oned and such fossils as have been found, either animal or plant, have
in consequence had but slight if any stratigraphic value, and reflect
shifting environments and changing geographical distribution among
groups of organisms whose specificity was, for the most part, un-
changed throughout the whole interval from early Pleistocene to
modern times.

It is not my purpose to attempt a history of opinion of the Coastal
Plain terrace formations or to discuss them formally within even the
limits of Maryland, and the foregoing remarks are made as intro-
ductory to a consideration of certain local observations.

Dr. C. W. Cooke, who has written considerable on the Coastal
Plain terrace formations, advocates a revised terminology for the
younger ones[2] and proposes that the name Talbot terrace, which de-
rives from Talbot County on the Eastern Shore, be retained for the

[1] Received October 4, 1940
[2] COOKE, C. W. Journ Washington Acad Sci. 21: 503–513. 1931.

42-foot level and that for a younger Talbot stage observed in some places in Maryland the name Pamlico be extended from North Carolina, where this stage is beautifully developed. The Pamlico has an altitude of about 25 feet and has been recognized in Prince Georges County and the District of Columbia at both of which it has furnished a considerable flora.[3] C. K. Wentworth[4] recognized a still lower level in Virginia for which he proposed the name Princess Anne, which has an altitude of about 12 feet. Cooke dissents from this proposal of Wentworth's. If accepted, both the Airport deposits and those at Wagners Point, which are discussed in the following pages, would be referred to the Princess Anne stage of the late Pleistocene, although it is possible, but not demonstrable, that traces of older Pleistocene deposits are shown in the test borings at the Airport.

MUNICIPAL AIRPORT

Through the cooperation and intelligent interest of W. Watters Pagon, consulting engineer on the Baltimore Airport, I am indebted for samples and for the records of a series of test borings. The former have furnished a few identifiable plants from the deposits and the latter some interesting data on changing conditions and less clear indications of past changes of level. They show, for one thing, considerable erosion in the Cretaceous surface previous to the deposition of the Pleistocene. At the Airport the Cretaceous is encountered about 60 feet below tide, whereas on the opposite shore of the Patapsco and a couple of miles down the dip near Hawkins Point the Cretaceous rises to a height of 24 to 28 feet above tide.

The borings show also considerable thicknesses of carbonaceous clays with plant remains, possibly marsh deposits, separated by two or three intervals of coarser water laid and presumably stream deposits. These might be interpreted as due to alternating times of elevation and depression and as referable to different-named stages in the Pleistocene, but since exact lithological correlations are impossible between adjacent borings I am inclined to think that the major factor is shifting conditions—what might be called "scour and fill"—rather than changes in level, although minor changes must inevitably have occurred.

The plants found in the clays (mud) include (1) badly decayed dicotyledonous wood, otherise unidentifiable; (2) leaf fragments and an

[3] BROWN, R W   op cit   and BERRY, E. W   Journ Washington Acad Sci **23:**
1-25   1933
[4] WENTWORTH, C K.   Virginia Geol Survey Bull. **32**   1930

acorn cupule of *Quercus* sp.; (3) a seed and numerous leaf fragments of *Fagus americana*.

WAGNERS POINT

On the south bank of the Patapsco between Wagners and Fishing Points, directly across from the Airport, the land surface is only a few feet above tide. Excavations for a WPA sewer project have thrown out a large amount of material. Its lithologic similarity to that encountered in the borings at the Airport led to its careful examination, although no information was obtainable as to its stratigraphic relations. Considerably more identifiable plants were found in these deposits. The material is a very silty uncompacted dark grayish, often very micaceous clay, with scattered quartz pebbles, full of leaf fragments mostly very much broken and thoroughly macerated. Obviously stream lain and apparently in a backwash or eddy on a tidal flat. An occasional seed, small broken sticks and fragments of bark, pieces of acorns or cupules, husks and nuts of a hickory, etc.

I have seen innumerable cove beaches in the estuaries around Chesapeake Bay where the material is of the same silty texture and where at low tide one observes fragments of oak or similar coriaceous leaves, occasional sticks or hard fruits and pine cones that seem to me to duplicate the conditions during the Pleistocene in this general region. This is especially true of the sediments as well as the plant contents in the material from Wagners Point.

The plant material consists of the following:

Pinus virginiana (Mill) A single small cone-scale This is still a common species hereabouts and according to Chrysler forms both pure stands and mixed pine-oak associations in southern Maryland In its wider range it extends from Long Island, N Y, to South Carolina in the Coastal Plain. It has not previously been found fossil

Taxodium distichum (L.) L. C. Rich. The bald cypress is found in the Coastal Plain Pleistocene at innumerable localities from New Jersey to Florida and Louisiana. These are usually of Talbot or Pamlico age, but some very large stumps were encountered in excavating for the Mayflower Hotel in Washington,[5] which are referred to the Wicomico formation. It is present in the clays at Wagners Point by detached leaves, which are very characteristic when first collected. At the present time the bald cypress reaches its northern limit in southern Charles County, but during the Pleistocene it ranged northward as far as New Jersey and in this latitude it ranged inland to the Fall Line, or even beyond.

Hicoria ovata (Mill.) Britton. A single nut and many nearly complete sections of the very thick husks. In general this is now a rich soil species ranging from Canada to western Florida, Alabama, and Mississippi. Accord-

[5] BERRY, E W   Journ Washington Acad. Sci 14: 15, pl. 1, figs 37–42, pl. 3. 1924

ing to Chrysler it is frequent in what he calls Oak-Hickory association in southern Maryland. *Hicoria ovata* has a large number of Pleistocene records including Pennsylvania, Maryland, District of Columbia, and North Carolina. It occurs in deposits correlated with the Pamlico formation both in the District of Columbia and Prince Georges County, Md

Alnus rugosa (Du Roi) K Koch. A leaf. The alder is common on wet soil in Maryland, ranging northward to Maine and southward to Florida and Texas. *Alnus rugosa* has been recorded from the Talbot of Drum Point, Md., and the Pamlico of the District of Columbia.

Fagus americana Sweet. Many leaf fragments and an immature fruit. The beech is widespread in the Coastal Plain Pleistocene from Pennsylvania to Texas Its modern range is from Ontario to Florida, and it is not uncommon in tidewater Maryland.

Quercus sp. Small fragments of bristle-tipped lobes of oak leaves are rather common. They are too incomplete for specific determination but represent *rubra, velutina,* or *digitata.* The first of these has been recorded from the Pamlico of Prince Georges County.

Vitis cf. *cordifolia* Michaux. A single characteristic seed, probably of this species. Grape seeds are common in the Coastal Plain Pleistocene from New Jersey to Louisiana and are widespread in the Talbot of Maryland

OSTREA VIRGINICA IN THE COLGATE DISTRICT OF EAST BALTIMORE

An interesting specimen is a large fragment of "coquina" made up of fragments of the common *Ostrea virginica* collected at the borrow pit from which the City of Baltimore is taking fill for the Municipal Airport. The specimen was turned over to the consulting engineer by a workman, and the approximate depth was 8 or 9 feet below the surface at the base of the gravels, which are supposed to be of Sunderland age and close to the contact with the underlying Upper Cretaceous The altitude is about 100 feet. The location is at the corner of the proposed extensions of Boston Street and the Broening Highway.

There are a number of considerations that can not now be verified before the authenticity of the find can be accepted. If we assume that it was collected in place, the oyster bed should be more extensive. Oyster spat would hardly set and grow to maturity in a rapidly forming gravel deposit. It might be concluded that the pieces were torn from a contemporaneous oyster bed and deposited with the gravel. The depth at which the specimen was found precludes its having come from a refuse dump of some oyster cannery or old shell road or Indian kitchen midden. The last would hardly be likely to occur at a distance from the present shores; an old road fragment would hardly be so cleanly washed.

If the specimens are actually indigenous in the Sunderland it is the first record of marine or estuarine fossils in any of the Maryland terrace formations older than the Talbot. *Ostrea virginica* occurs abun-

dantly in the Talbot of Calvert, St. Marys, Talbot, and Caroline Counties, Maryland. The present record is much more remote from modern marine waters and, if authentic, goes a long way toward substantiating the accepted theory of the marine origin of the Pleistocene terrace deposits.

WHITE OAK FROM BED OF CARDIFF AVENUE

I am indebted to W. W. Pagon for a specimen of a small stump of some species of the white-oak section of *Quercus* collected from the bed of Cardiff Avenue, 250 feet east of the Broening Highway. This was found 12 feet below the present surface and may be of Wicomico age. The specimen is of the extreme base of a stump and is about 8½ inches high, worn to a pointed top and rotted to a hollow on the under side.

Anatomical features afford no satisfactory basis for differentiating species among the white oaks. Of the recent species of white oaks in the Coastal Plain of this latitude *Quercus alba* occurs abundantly in the Pleistocene from the Interglacial of Canada (Don River) to North Carolina and Tennessee. In Maryland it is found in the Sunderland of Calvert County and the Pamlico of Prince Georges County; *Quercus lyrata* occurs in the Pleistocene of North Carolina, Louisiana, and Texas.

HEMLOCK FROM BRIGHTSEAT, PRINCE GEORGES COUNTY

Perfectly characteristic cones of *Tsuga canadensis* (L.) Carriere were collected by Dr. Charles T. Berry from the Pleistocene overlying the Monmouth Upper Cretaceous at the well-known Monmouth fossiliferous exposure near Brightseat, Prince Georges County.

Previous fossil records of hemlock are from peat deposits in southeastern Canada[6] and from Pamlico deposits along Northwest Branch Anacostia River in Prince Georges County, Md., where both wood and cones have been found.[7]

In the modern flora this tree is found from Nova Scotia to eastern Minnesota, southward to northern Delaware and along the Appalachians to northwestern Alabama (Sargent). In Maryland it is known naturally from but a single locality in the Coastal Plain (Watts Creek, Caroline County) (Chrysler), a doubtful record; it is sparing in the Lower Midland Zone (Shreve), frequent in the Upper Midland Zone (Blodgett), and abundant in the Mountain Zone (Shreve).

[6] Auer, V. Geol Surv Canada Mem 162: 32   1930.
[7] Brown, R W   Journ Washington Acad Sci 25: 443   1935.

ZOOLOGY.—Contracaecum quincuspis, *a new species of nematode from the American waterturkey.*[1] JOHN T. LUCKER, U. S. Bureau of Animal Industry. (Communicated by E. W. PRICE.)

A female *Contracaecum* with lips and interlabia of remarkably complex structure was observed among some nematodes from the waterturkey (*Anhinga anhinga*) deposited in the U. S. National Museum Helminthological Collection. The only known species in which these structures vary conspicuously from the pattern usual in the genus is *C. tricuspis*[2] (Gedoelst, 1916) Baylis, 1920; but it was immediately apparent that the lips and interlabia of the specimen from the waterturkey differed from those described and figured for that species by Gedoelst (1916). Some specimens labeled *"Contracaecum tricuspe"* from *Anhinga anhinga* were available for comparison; but the lips and interlabia of these specimens and of the one originally examined by the writer were identical morphologically.

Other less striking discrepancies were also noted between the American specimens and *C. tricuspis*, which was originally described as *Kathleena tricuspis*, from a "Héron" from Belgian Congo. The species has subsequently been recorded by Baylis and Daubney (1922) from *Anhinga melanogaster* from India and by Baylis (1933) from the same host from Java.

It seems odd that two species of *Contracaecum* having elaborate lips and interlabia as their principal feature of difference from the pattern typified by such species as *C. microcephalum* and *C. punctatum* should occur in closely related hosts, even though the latter are from regions widely separated geographically. Nevertheless, the American specimens must be regarded as distinct from *C. tricuspis* on the basis of the present characterization of that species. Certainly there is no existing objective evidence, and no reason to assume or believe, that Gedoelst overlooked obvious and readily observed morphological features of the lips and interlabia of his species. From the nature of Baylis and Daubney's (1922) paper, which included descriptions of new species and redescriptions of previously known species of Anisakinae, it seems likely that these authors would have called attention to important discrepancies between Gedoelst's description and the Indian specimens identified by them, had any existed. Hence, the specimens from the American waterturkey are here described as a new species.

Contracaecum quincuspis n. sp. Figs. 1–7

Description —Lacking a distinct collar between anterior limit of cervical region and head, but with definite encircling gro͞ove marking junction of these regions (Fig. 1); posterior superficial margins of lips and interlabia discrete from anterior limit of cervical region. Cuticle of cervical region immediately behind lips not presenting "shirred" appearance. Lips and interlabia of complicated structure as follows: Each lip, viewed from without, with lateral margins deeply incised a short distance anterior to base, the notches or furrows extending nearly to median line of lip (Fig. 1). Outline of basal portion of lip, posterior to furrows, resembling a pair of wings connected to main body of lip by median construction or neck produced by incisions Main body of lip, bearing papillae of external circle, appearing more or less elliptical in outline; posterior and posterolateral margins formed by basal furrows; lateral extremities convexly rounded, anterolateral margins converging toward median line, but not meeting. Internal and anterolateral to anterior curvatures of main body of lip, winglike processes, more or less acutely pointed at their lateral extremities, visible in this view (Fig 1). *En face* view (Figs. 3, 4) shows that these processes represent lateral extremities of internal, more or less heart-shaped apex of lip, an anterior pair of incisions, passing from lateral extremities of lip toward median line and somewhat posteriorly, at first, then curving internally toward mouth axis and terminating some distance from tip of lip, separate heart-shaped apex from main body of lip, with only a narrow neck connecting the two Apical process considerably narrower than main body of lip, its straight anterolateral margins meeting at tip to form obtuse angle; its posterior portion, bounded by anterior pair of furrows, in form of an auricle-like lobe on each side of connecting neck Base of interlabium, viewed from without, comparatively narrow, discreet from base of neighboring lips (Fig. 2) Interlabium with a pair of slender, laterally directed processes originating just above base, each cusp fitting into complementary basal incision of neighboring lip. Superficial margins of interlabium anterior to basal pair of cusps, narrow, elongate, stemlike, passing between lateral margins of main body of neighboring lips. Stem broadening internally, with internal portion lying below lateral extremities of neighboring lips, and branching distally to form three cusps, an anterolaterally directed pair and a single short internally directed terminal cusp. Distal lateral cusps shorter than basal pair, fitting into complementary anterior incisions between main body and apex of neighboring lips Terminal median process rounded at tip, usually not detectable from without or in *en face* view, but readily seen if head is dissected (Fig. 3) Cuticular expansions passing from terminal cusp to distal lateral pair and from latter internally along stem Muscular esophagus long and very slender; ventriculus small, more or less rounded, or slightly elongate,

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Figs 1–7 —*Contracaecum quincuspis* n sp.: 1, Subventral view of head (female) tilted slightly upward; 2, ventral view of head (female) showing interlabium and its relationships with adjacent subventral lips; 3, *en face* view of dorsal lip and subdorsal interlabia from a dissection of head (female); 4, *en face* view of head (female), slightly oblique aspect; 5, lateral view of posterior extremity of female; 6, ventral view of posterior extremity of male tilted slightly toward the right, showing postanal caudal papillae and a few papillae of the preanal series (the protruding portions of the spicules had been cut off), 7, lateral view of posterior extremity of male, showing postanal papillae and a few papillae of the preanal series on the left side (Figs 5 and 7 are drawn to one-half the indicated scale)
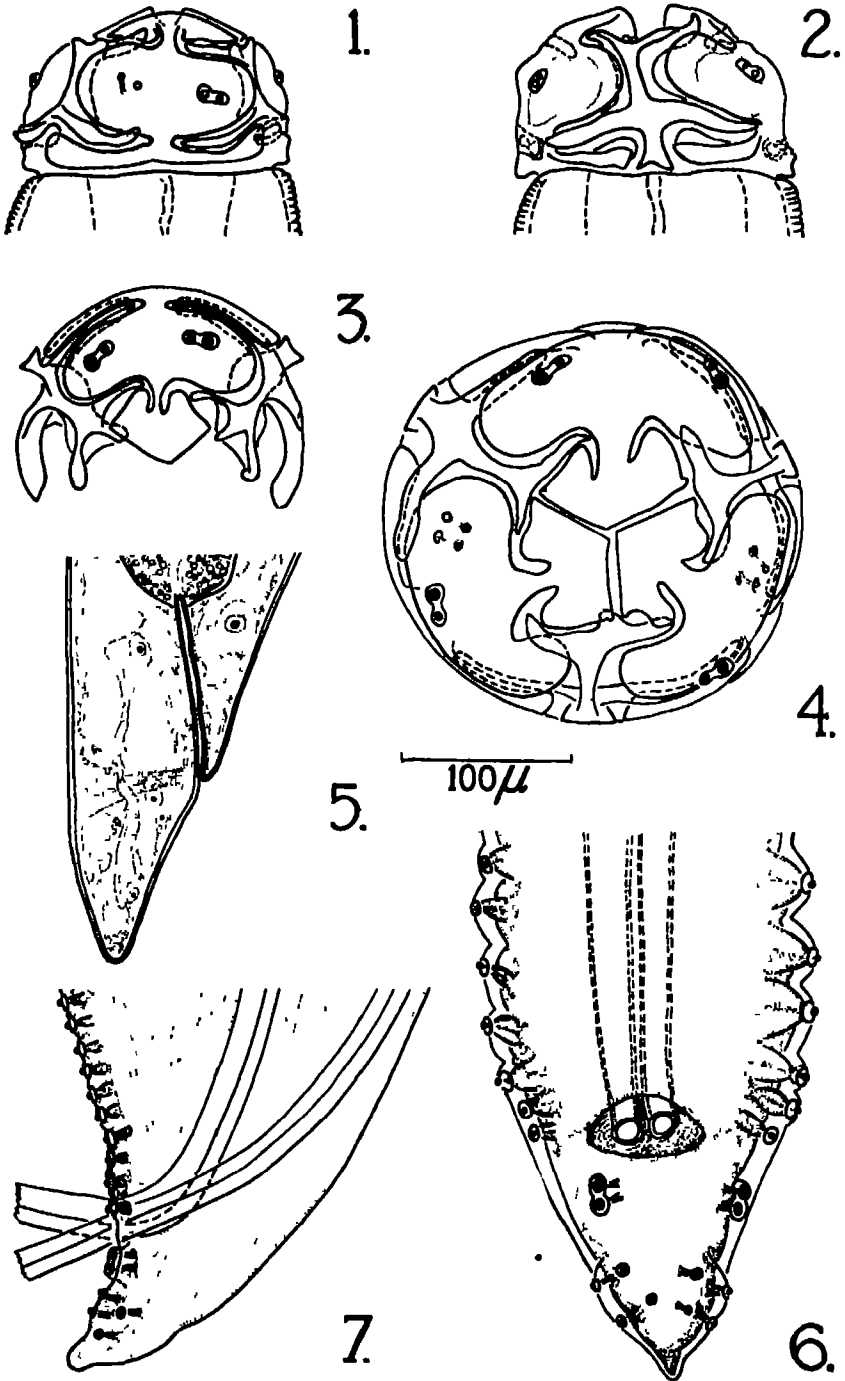
Figs. 1–7 —(See opposite page for explanation)

depending on state of contraction; appendix about one-sixth to one-fourth as long as esophagus; intestinal cecum long, extending almost to region of nerve ring, voluminous at origin, tapering to rounded anterior tip. Deirids slightly posterior to region of nerve ring. The principal size relationships of three male and three female specimens are shown in table 1.

TABLE 1 —PRINCIPLE SIZE RELATIONSHIPS OF CONTRACAECUM QUINCUSPIS n sp.

(All measurements in millimeters)

Measurement	Female			Male		
	Specimen 1	Specimen 2	Specimen 3	Specimen 1	Specimen 2	Specimen 3
Body						
Length	23 0	23 0	15 0	12 1	12 5	10 0
Maximum width	0 87	0 97	0 48	0 50	0 43	0 50
Distance from anterior end to nerve ring		—	0 20	0 38	—	0 28
Muscular esophagus						
Length	5 34	6 43	4 27	4 06	3 82	3 98
Average width	0 16	0 15	—	0 08	0 08	0 08
Esophageal ventriculus						
Length	0 18	0 19	0 15	0 10	—	0 13
Width	0 20	0 25	0 18	0 15	—	0 13
Esophageal appendix						
Length	0 85	1 18	1 05	0 95	1 27	0 64
Ratio of length to length of esophagus	1 6 4	1 5 5	1 4 2	1 4 4	1 3 1	1 6 4
Intestinal cecum						
Length	5 10	6 07	3 97	3 34	3 47	2 97
Ratio of length to length of esophagus	1 1 1	1 1 1	1 1 1	1 1 2	1 1 1	1 1 4
Length of tail	0 28	0 33	0 20	0 38	—	0 28
Vulva						
Distance from anterior extremity	8 15	10 27	7 43	—	—	—
Ratio of distance to body length	1 2 8	1 2 2	1 2	—	—	—
Length of spicules	—	—	—	2 83	2 03	2 24

Male.— Maximum length about 14 mm. Tail conical, curving ventrally, terminating in a small, more or less bluntly pointed ventral process About 40 pairs of sublateral preanal caudal papillae, consisting of a single more or less linear series in each sublateral field, the posteriormost papilla of each series adanal in position; six pairs of postanal caudal papillae consisting, of a subterminal group of two lateral and two subventral pairs and two prominent subventral double papillae in region between terminal group and posterior lip of cloaca (Figs. 6, 7). Spicules approximately equal, about 3.7 to 4.25 mm. long in apparently fully grown specimens; minimum observed length in smaller specimens slightly more than 2 0 mm

Female.—Maximum length about 23 mm Tail conical, tapering gradually to rounded tip, lacking cuticular or hypodermal processes (Fig 5). Vulva slightly prominent, distance from anterior end of body about 35 to 49 percent of body length The available specimens did not contain fully developed eggs

Host.—*Anhinga anhinga.*

Distribution.—Florida, Arkansas, District of Columbia (National Zoological Park).

Specimens.—U. S. Nat. Mus. Helm. Coll. no. 44559 (holotype; male), 44560 (allotype), 30591 (paratypes), 30592 (paratypes).

Remarks —*Contracaecum quincuspis* differs from *C. tricuspis*, as described and figured by Gedoelst (1916), in the following respects: The lateral margins of the lips are deeply incised near the base and also anteriorly between the main body of the lip and the internal apical process; in *C. tricuspis* the lips are notched anteriorly between the apex and the remainder of the lip, only. In *C. quincuspis* the superficial basal margins of the lips and interlabia are discrete; the basal margins of the lips and interlabia are figured as continuous in *C. tricuspis* In *C. quincuspis*, each interlabium gives rise to five cusps or branches, a prominent long slender lateral pair, originating near the base, a shorter anterolateral pair, and a terminal internal one; the interlabium of *C. tricuspis* bears only the three distal cusps. In *C. quincuspis* two double subventral caudal papillae occur a short distance behind the cloaca of the male; the corresponding papillae are not described as double in *C. tricuspis.* In both species the preanal series of caudal papillae terminate posteriorly laterally to the cloaca so that one or two pairs of these papillae are actually adanal in position In *C. tricuspis*, however, a subventral papilla, median to the preanals and not aligned with them, is present close to each side of the cloacal opening, such an adanal pair is lacking in *C quincuspis* In some specimens of *C quincuspis* the preanal series were observed to curve toward the median line as they neared the cloaca, the most posterior pair of papillae being more or less subventral in position, although clearly part of the preanal series In *C. quincuspis* about 40 pairs of papillae comprise the preanal series; in *C. tricuspis* about 56 pairs are said to be present. In cases of convergence in all other important characteristics, these differences in the arrangement of the adanal and postanal papillae and in the number of preanal papillae would be regarded as normal intraspecific variations or as merely representing differing interpretations. But, in this instance they deserve emphasis because they are correlated with the presence of lips and interlabia which, so far as can be judged, are of characteristically divergent structure. Finally, in *C quincuspis*, the esophageal appendix is about one-sixth to one-third as long as the esophagus; Gedoelst's measurements indicate that in *C. tricuspis* the appendix is about one-half as long as the esophagus.

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ENTOMOLOGY.—*Butterflies of Farmville, Virginia.* AUSTIN H.
CLARK, U. S. National Museum, and FRANK W. TRAINER, University of Virginia.[1]

Farmville, the county seat of Prince Edward County, is in south-central Virginia, approximately in the middle of the Upper Austral or Carolinian Zone between the Lower Austral Zone to the east and the Transition or Alleghanian Zone, which includes the mountainous regions in the western part of the State. The country about Farmville has been under intensive cultivation, and all the original forest cover has long since disappeared. Patches of second-growth woodland and a few boggy areas may be found.

There are no published records of butterflies for the region in which Farmville is situated with the sole exception of a notice of the occurrence of *Neonympha areolatus septentrionalis* at Lunenburg.[2] The present paper is based upon intensive studies made by the junior author in the spring and summer of 1940, supplemented by collections made in 1937, 1938, and 1939, when a few species were taken that were not found in 1940. The senior author has in different years collected and taken notes in 3 localities in Prince Edward County and at 26 localities in the surrounding counties—Charlotte, 2; Appomattox, 2; Buckingham, 7; Cumberland, 4; Amelia, 3; Nottoway, 4; and Lunenburg, 4—and these notes have served as a background for the interpretation of the Farmville fauna.

The number of species recorded from Farmville in the following list is 73, to which are added three from nearby regions that are quite likely to be found at Farmville. The total number of species is about half the number known from Virginia. But many species in Virginia are confined to the Transition Zone or Canadian Zone in the western mountains, or to the Lower Austral Zone on the Coastal Plain. It is possible that several species have been extirpated by the intensive cultivation of the land. Future collecting will undoubtedly add a number of species, some of highly localized occurrence, but most more or less casual visitors, especially from the south.

In the following list only the earliest and latest dates are given unless there is a significant gap in the records, or unless records are few. When no year is mentioned 1940 is understood.

Family NYMPHALIDAE: Subfamily SATYRINAE: *Neonympha gemma*
(Hubner), IV 25 to V.8; VII.5; VIII 4 to IX.8. *Neonympha areolatus sep-*

[2] Jour Washington Acad Sci 27: 212 1937.

tentrionalis (Davis), not found at Farmville but taken by the senior author at Lunenburg, IX.2.1936 and IV.23.1939, and at Nottoway Falls, IV.23. 1939. *Neonympha eurytus* (Fabricius), V.26 to VII 30. *Neonympha sosybius* (Fabricius), V.12 to VI.16; VII.14 to IX.8. *Minois pegala alope* (Fabricius), VII.3 to IX.9; also VI.20 1937 and IX.19.1939. *Satyrodes eurydice* (Linné), VII.4 to IX 1.

Subfamily NYMPHALINAE: *Polygonia interrogationis* (Fabricius), III.16 to V.14; VII.14 to IX 8; one of the dark form V 14. *Polygonia comma* (Harris). III.17 to V 7. *Nymphalis antiopa creta* (Verity), IV.1 to V.26; also III.26 and X.10.1939. *Vanessa atalanta* (Linné), V 11 to VI.3; VI 28 to IX 8. *Vanessa virginiensis* (Drury), IV.11 to V 26; VI.19 to IX 8 *Vanessa cardui* (Linné), VII 10 to 23; VIII.20 to IX.17; not found in 1937, 1938, or 1939. It was not found anywhere in Virginia by the senior author in these three years *Precis coenia* (Hübner), VI 1 to IX 8. *Basilarchia arthemis astyanax* (Fabricius), V.22 to IX 9. *Basilarchia archippus* (Cramer), VII 6 to IX.1, not common. *Phyciodes nycteis* (Doubleday and Hewitson), not found at Farmville but taken by the senior author at Lunenburg, IX.2 1936 *Phyciodes tharos* (Drury), V.2 to IX.10 *Argynnis cybele* (Fabricius), V 31 to VIII 31; in 1937, V 28 *Euptoieta claudia* (Cramer), VII.26; IX.1, 7.

Subfamily DANAIINAE: *Danaus plexippus* (Linné), V.27 to IX.10; more common in early and midsummer than usual.

Subfamily LIBYTHEINAE: *Libythea bachmani* (Kirtland), VIII 3, 23; IX.14.

Family LYCAENIDAE: Subfamily SPALGINAE. *Feniseca tarquinius* (Fabricius), IV.17; VII 4, 5

Subfamily LYCAENINAE: *Lycaena phlaeas hypophlaeas* (Boisduval), IV.25 to VII.7; in 1937, IV 8 *Lycaenopsis argiolus pseudargiolus* (Boisduval and LeConte), III.31 to VII.14, also VIII 12,1939 *Everes comyntas* (Godart), IV.7 to IX 9

Subfamily THECLINAE: *Eupsyche m-album* (Boisduval and LeConte) IV 17, two on redbud; IV 29, one on apple blossom. *Strymon titus mopsus* (Hübner), VI.14 to VII.14 *Strymon liparops* (Boisduval and LeConte), VI.30. *Strymon falacer* (Godart), VI.9 to VII.22. *Strymon melinus* (Hübner), IV.25 to IX 8. *Calycopis cecrops* (Fabricius), V.5 to IX 8; also IV 30 1939 *Mitoura gryneus* (Hübner), V 5 to VIII.11 *Incisalia niphon* (Hübner), VI.30 (only one seen); in 1937, in April.

Family PAPILIONIDAE: Subfamily PIERINAE: *Pieris rapae* (Linné), III 28 to IX 10 *Pieris protodice* Boisduval and LeConte, III 29 to VIII 17. *Anthocharis genutia* (Fabricius), IV.4 to 5.V. *Phoebis eubule* (Linné), IV 24 1939; IX 19.1937; not seen in 1940. The senior author found it at Farmville, IV.24.1939, at Goochland Court House on the same date, and at Blackstone, Nottoway County, IV.23.1939 It is unusual to find this butterfly in Virginia in spring. *Colias philodice philodice* Godart, IV.16 to V.16; IX 8, 9; also III.27 1939. *Colias philodice eurytheme* Boisduval, form *ariadne*, IV.3 to V.26; form *eurytheme*, V.5 to IX.9; in 1939 to XI.29. *Eurema nicippe* (Cramer), IV.16; IX 1. *Eurema lisa* (Boiduval and LeConte), VII.19 to IX.10; also X-30 1938.

Subfamily PAPILIONINAE: *Papilio philenor* Linné, IV.17 to IX 7 *Papilio polyxenes asterius* Cramer, IV.10 to IX.10. *Papilio cresphontes* Cramer, IX.4 (seen). *Papilio glaucus* Linné, IV.4 to IX.7, in 1939, III 26. *Papilio troilus* Linné, IV.10 to IX.10. *Papilio marcellus* Cramer, IV 10 to VIII 24; seldom more than a few seen each season; more frequent than usual in 1940.

Family HESPERIIDAE: Subfamily PYRGINAE: *Epargyreus clarus* (Cramer), IV.29 to IX.10; in 1939, IV.26. *Achalarus lyciades* (Geyer), V.26 to

VIII.26. *Rhabdoides cellus* (Boisduval and LeConte), VIII.11. *Thorybes bathyllus* (Smith), V.5 to IX.10; in 1939, IV.30. *Thorybes pylades* (Scudder), V.25 to VIII.6. *Thorybes confusis* Bell, VI.6 to.VIII.8. *Pyrgus communis* (Grote), V.16 to IX.9; in 1937, V 9. *Pholisora catullus* (Fabricius), V.7 to IX.1. *Erynnis icelus* (Scudder and Burgess), not found at Farmville; the authors took it at Morven, Amelia County, IV.28.1940. *Erynnis brizo* (Boisduval and LeConte), IV.29; V.5, 13; also III.27.1938. *Erynnis martialis* (Scudder), V.19; VII.7, 21 26; VIII.9, 18; also V.16 and VII.10.1937. *Erynnis juvenalis* (Fabricius), IV.7 to V.5; also III.27.1938. *Erynnis horatius* (Scudder and Burgess), V.5. *Erynnis zarucco* (Lucas), V.19; VII.7. This butterfly has not heretofore been found in spring in Virginia.

Subfamily ·HESPERIINAE: *Ancyloxypha numitor* (Fabricius), V.21, 28; VI.3, 12; VII.11 to IX.9. *Hesperia metea* (Scudder), V 5 to 26; not common. *Hesperia attalus* (W. H. Edwards), form *seminole* (Scudder), VI.9; one female. This is the first record for Virginia. An earlier record (Proc Biol. Soc. Washington **51**: 5. 1938) was based on a misidentification. A specimen quite similar to the one from Farmville was taken by the senior author at Clarks Gap, Loudoun County, IX.22.1940. Both specimens are now in the U. S. National Museum *Hylephila phylaeus* (Drury); not found in 1940; VIII 30. 1939 *Atalopedes campestris* (Boisduval), V.31; VII 7 to IX 9. *Polites verna* (W. H. Edwards), VI 2; VIII.11, 18; in woods. *Polites manataaqua* (Harris), VI.2, 23; VIII.18; XI 1, 9; also V.29.1937. *Polites themistocles* (Latreille), V.26 to IX 10 *Polites peckius* (Kirby), VIII.18. *Wallengrenia otho egeremet* (Scudder), VII 30 to IX.1; also VI.13 1937. *Poanes zabulon* (Boisduval and LeConte), V.15 to VI 2; VIII 11 to IX 1. *Atrytone ruricola* (Boisduval), VI.30; VIII.11, 18 *Atrytonopsis hianna* (Scudder), V.12 to VI.2; in waste fields *Amblyscirtes vialis* (W H Edwards), V.17, 26; VI 6; VIII.11. *Lerodea l'herminier* (Latreille), VI 9, 23; VIII.11 to IX 8; also V 27.1938.

GEOCHEMISTRY.—*Time and temperature effects in the formation of colloidal dispersions.*[1] P. G. NUTTING, U. S. Geological Survey.

Many colloids disperse in water much after the manner of salts going into solution. There is commonly a concentration limit or solubility, affected by temperature and by the presence of other salts or colloids. The rate of dispersion depends upon the same factors affecting rate of solution. The concept of peptization is evidently too narrow to deal with colloidal dispersion. On the other hand, dispersions may be treated as solutions if their common tendency to reaggregate in micellae of a wide size range (comparable to polymerization in ordinary chemistry) be kept in mind. With complex colloids in acid solution, dispersion and solution may occur together, and the study of such solutions throws much light on many soil and geologic problems.

The writer has investigated at some length the behavior of various montmorillonite clays in acids of various concentrations and various ratios of acid to clay.[2] In these studies a 48-hour digestion at 90° C. was commonly used. Here reported are digestions at 90°, 3 hours to 11 days, and at 28°, 1 to 128 days, each in 8 steps. The latter shows an interesting case of recombination of ions with colloidal micellae well worth recording.

The clay used was the purest montmorillonite bentonite known, from the Vicksburg formation near Polkville in central Mississippi. It is practically 100 percent crystalline, and most of the crystals (montmorillonite) are assembled in shard relicts indicating that no reworking had occurred. For use it was withdrawn from storage in a saturated atmosphere and room-dried to permit grinding to 150 mesh (0.1 mm). Twenty grams of this clay was put in 4 liters of 0.4 percent HCl previously brought to temperature (28° for one run, 93° for the other) and vigorously stirred at intervals. At the stated time inter-

vals, 400 cc of solution was withdrawn and filtered for analysis. The filtration, through the clay itself on Whatman 42 paper, was continued until the filtrate showed little or no scattered light (Tyndall beam) in a very strong light beam. This means an upper limit to particle size of less than 0.1 micron.

These 400-cc portions of filtrate were evaporated to dryness in

TABLE 1.—SOLUBILITY OF CLAY AT 93° C.

Time of treatment	Water insoluble	Soluble R_2O_3	Soluble CaO	SiO_2	Combined R_2O_3	$\dfrac{SiO_2}{Insoluble}$	$\dfrac{Combined\ R_2O_3}{SiO_2}$
3 hours	0 2572	None	0 0630	0 1652	0 0343	0 642	0 208
7 hours	0 4732	None	0 0951	0 2962	0 0979	0 626	0 330
24 hours	0 8588	None	0 0961	0 4918	0 1912	0 573	0 389
2 days	1 2500	0 0238	0 0966	0 6295	0 2932	0 504	0 465
4 days	1 5671	0 1518	0 1071	0 8628	0 3748	0 551	0 434
6 days	1 7648	0 1786	0 1280	0 8484	0 4754	0 481	0 560
8 days	1 7639	0 2036	0 1424	0 8472	0 5100	0 480	0.603
11 days	1 7731	0 2425	0 2019	0 8492	0 5508	0 479	0 684
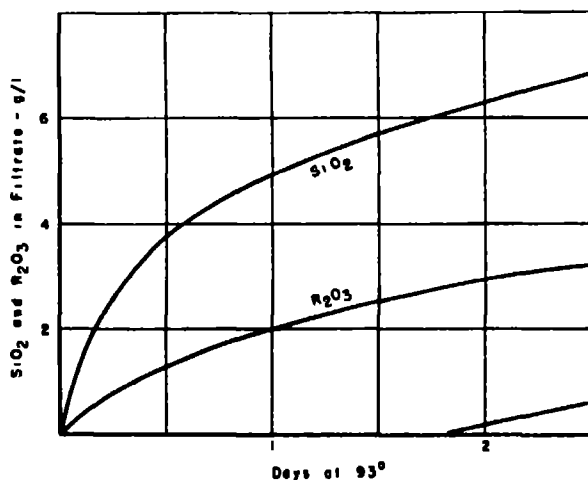
Fig 1.—Solubility of clay at 93° C.

150-cc pyrex beakers, then put in an oven at 160° for an hour to remove all free moisture. Check tests showed no appreciable vaporization or insolubilization of the mixed chlorides (chiefly of Al, Fe, and Ca with traces of Na and K) present by this treatment. After the total residue was weighed, water soluble chlorides were removed by boiling 10 minutes in distilled water, decanting, and the residue again dried at 160°. This water-insoluble residue, after weighing, is wet with

concentrated HCl, then treated with about 15 cc of hot 20-percent HCl for 30 minutes to separate bases from silica.

The results obtained at 93° are given in Table 1 and graphed in Fig. 1, expressed in grams per liter.

As regards silica and water-insoluble residue, the solution appears to approach saturation in about 4 days, half saturation in about 1 day. Silica approaches 0.85 gram per liter as a limit, water-insolubles 1.8. Water-soluble R_2O_3 first appears in the 2-day digestion but combined R_2O_3 appears in 3 hours. Both forms of R_2O_3 appear to be still increasing after 11 days. The CaO in this clay is not all removed at the start as with some clays, but only about a third in the first 3 hours. Calcium does not recombine (like part of the R_2O_3) in this dilute acid solution. A pH of 1.56 was taken after 8 days. After 5 months at room temperature (28°) the pH of this solution was 0.93, and the water soluble R_2O_3 had decreased to nothing.

In the original clay, SiO_2 was about 68 percent of the total solids. In these solutions that ratio starts at 64 and drops toward 48, which is below the $Al_2O_3 2SiO_2$ ratio. In the clay, R_2O_3/SiO_2 is about 0.40, while in the washed residue that ratio ranges from 0.2 to nearly 0.7 and is still rising in the 8–11 day interval. Pure silica is soluble in water at 90° to the extent of 0.418 gram per liter, less than half the maximum (0.85) here attained. Acid depresses the solubility of silica in water, but by dissolving bases from the clay it releases silica to go into solution in the water and there recapture the bases previously associated with it. MgO constitutes 4.5 percent of this clay, but no more than traces were ever found in solution. The chlorides of aluminum and iron undoubtedly hydrolize in solution, thus setting free more acid as these bases reunite with silica. Until these chlorides leave the clay, the associated water is insufficient for hydrolysis.

At 28° the solution of clay in 0.4 percent HCl is not only very much slower, but an essentially different process. As before, 20 grams of 150-mesh Polkville clay was put in 4 liters of 0.4 percent hydrochloric acid in a pyrex flask. The temperature of the room (air conditioned) seldom rose above 29° or fell below 27° and then only for brief periods. At intervals, 400-cc portions were withdrawn, filtered, and analyzed as described above. The results (in grams per liter) are shown in Table 2 and graphed in Fig. 2.

No trace of water-soluble R_2O_3 was found in any of the first residues; all that is dissolved from the clay recombines with the silica in solution. There is no indication of any saturation limit being approached in 128 days. Silica apparently passes through a minimum

TABLE 2.—SOLUTION OF CLAY IN ACID AT 28° C.

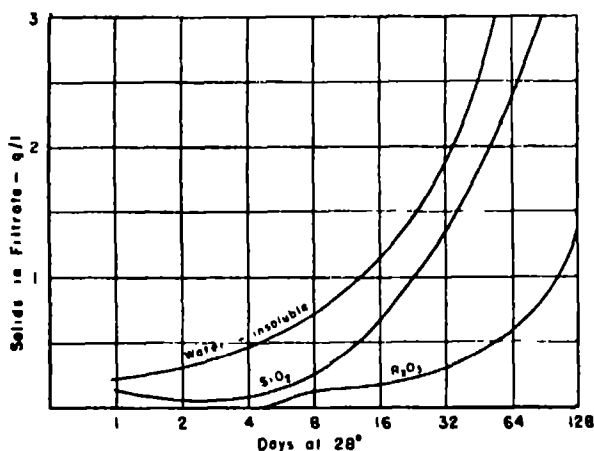| Days of treatment	Water insoluble	CaO soluble	SiO₂	Insoluble R₂O₃
1	0 0220	0 0837	0 0141	0 0007
2	0 0337	0 0751	0 0066	Trace
4	0 0425	0 0760	0 0098	None
8	0 0796	0 0727	0 0258	0 0136
16	0 1157	0 0929	0 0617	0 0177
32	0 1984	0 0938	0 1157	0 0281
64	0 4061	0 1026	0 2469	0 0605
128	0 6506	0 1136	0.3682	0 1492

Fig. 2.—Solubility of clay at 28° C.

during the first few days, then rises steadily. Water-insoluble solids increase from the start. Recombined R_2O_3 appears after 4 days, remains low for a month, then rises rapidly. The ratio SiO_2/water-insoluble remains approximately constant (average 0.58) instead of decreasing to a minimum as it does at 90°. The saturation limit for pure silica (0.195 gram per liter at 28°) is passed in about 50 days and is nearly double this in 128 days.

The adsorption of ions on colloidal micellae is well known to chemists. The results here reported afford a quantitative view of the mechanism of one such process familiar to geologists in which the micellae are submicroscopic and approach true solution.

In soils, alternately wet (with slightly acid water) and dried, conditions are evidently very favorable for the formation of montmorillonitic particles from the mother rock substance. Soil acids dissolve the bases while water dissolves the silica. In solution, the salts hydrolyze (as they could not in the rock), and the bases recombine with the

silica. Drying precipitates the colloid. The occurrence of montmorillonitic clays in rock seams or filling cavities in quartz crystals and as replacements of shells and decomposed granite is readily understandable. Elements not needed in the recombination are excluded; thus dendrites of manganese oxide and specks of chromite and biotite are commonly found associated with clays of this type.

Many possible disturbing factors were investigated and may be briefly mentioned. Adding excess acid to the filtrate before evaporation does not affect the analysis, nor does the addition of ammonia up to the point where precipitation begins. If excess pure silica solution is added, that silica remains uncombined with the bases. In one series of tests, sodium fluosilicate, Na_2SiF_6, was added in varying amounts from 0.01 to 0.14 gram in 400 cc of clay solution, but no effect on the silica or on either soluble or insoluble R_2O_3 was found. The anion effect in solution analysis is large. Oxalic, phosphoric, and sulphuric acids depress or inhibit recombination (of R_2O_3 with silica) in solution, while nitric acid forces all R_2O_3 into combination with silica, despite the high concentration reached during evaporation. The behavior of clays in different acids will be reported in a later paper.

SUMMARY

Solutions of montmorillonitic clay in dilute hydrochloric acid, at either 28 or 90° C., may contain more than twice the silica of a saturated solution of pure silica in water.

Part of the sesquioxides leave the clay and combine with silica to form submicroscopic colloidal particles recoverable by evaporation.

At 90° equilibrium is approached in 4 days; at 28° solution curves are still rising after 128 days.

The possible bearing of these results on the formation of clay colloids in rock cavities and soils is discussed.

BOTANY.—*Naming the cultivated rubber tree* Siphonia ridleyana.[1] O. F. Cook.   U. S. Bureau of Plant Industry.

As indicated in Science,[2] historians of the rubber industry are seriously misled by confusion among the names of different trees in South America. The usual designation of the cultivated rubber tree is *Hevea brasiliensis*, but this is ambiguous on account of being borrowed from two other rubber trees. The generic name *Hevea* was transferred from a tree found by La Condamine in 1736 on the Pacific coast of Ecuador, and the specific name *brasiliensis* from a tree that Humboldt and Bonpland collected on the upper Orinoco in 1800. The generic name *Siphonia* has historic warrant for replacing *Hevea*, as will be explained. The specific name *Siphonia ridleyana* is suggested to commemorate the discovery by Henry N. Ridley of the method of extracting the rubber-bearing latex of this tree, which may be reckoned among the major events of history. No other domestication or introduction of a plant has such marked reactions on human affairs. The rubber discovery was made at the Singapore Botanic Gardens in 1889, as recounted by David Fairchild in the Journal of Heredity for May, 1928, from notes of a visit to Ridley in 1896.

Giving the cultivated rubber tree a name of its own may assist in clarifying some of the problems of production. This tree has been the subject of intensive investigation in the East Indies, but has had relatively little study in tropical America. The cultural problems are not the same in America, and a different approach is necessary on account of the *Castilla* or Central American rubber tree being much better known in most of the American countries. The original habitat of the cultivated rubber tree was in the lower Amazon Valley, while *Castilla* extended through tropical America from Mexico to Peru, Bolivia, and Brazil, several species being recognized.

Without Ridley's discovery there would have been no commercial planting of *Siphonia* in the East Indies, higher prices would have ruled, and some of the *Castilla* plantations in Mexico and Central America would have been profitable. In that event the planting of *Castilla* might have extended through tropical America and our present dangerous dependence on the East Indies would not have occurred. Markham's project of cultivating rubber in the East Indies would have miscarried, and Wickham's rape of the Brazilian rubber tree, dramatized by so many historical writers, could have had little significance. The industrial utilization of rubber doubtless would have

gone forward but in different courses and much more slowly. The exploitation of wild rubber in Brazil would have been carried into more remote forests, with increasing difficulty and hardship among the laboring people, till cost limits were reached, or demands could be met from planted *Castilla* rubber. Planting *Siphonia* in Brazil was not feasible under the native method of tapping, and the native leaf disease is another obstacle not yet surmounted.

CASTILLA THE ORIGINAL RUBBER TREE

A general priority may be claimed for *Castilla* as a source of rubber, not only in Mexico and Central America, but also in South America. The labor required for gathering *Castilla* rubber is much less than with *Siphonia*, on account of the latex being more abundant and flowing more freely, but the trees are destroyed. It was not till the middle of the nineteenth century, after *Castilla* had been exhausted along the Amazon, that the Para rubber tree began to be exploited on a large scale. The extinction of *Castilla* is explained by the method of tapping, the trees being felled and ringed with tapping cuts at frequent intervals along the whole length of the trunk and the larger branches. Fifty pounds of rubber may be obtained from a large *Castilla* tree, though most of the latex remains in the bark. *Castilla* rubber is essentially the same as *Siphonia* rubber, but requiring different treatment, like cane sugar and beet sugar.

The idea of replacing the natural resources of wild rubber with cultivated trees was entertained much earlier in Mexico, some of the planted *Castilla* trees dating back to 1867, nearly 30 years in advance of the commercial planting of *Siphonia* in the Malay Peninsula. Thousands of acres were set with *Castilla* trees in southern Mexico near the end of the last century, before the East Indian rubber industry was developed. But Ridley's method of tapping could not be applied to *Castilla*, and the Mexican rubber plantations became a complete failure.

The differences between the two principal types of rubber trees need to be clearly understood, and also the nature of Ridley's discovery, before the problems of utilization can be approached to full advantage in tropical America. The *Siphonia* tree, because it was limited in nature to Brazil and as yet has been cultivated chiefly in the East Indies, comes to most of the American countries as a new introduction, and inevitably is viewed from the standpoint of experience with the local *Castilla* tree, which proved disappointing. *Siphonia* often appears less promising than *Castilla*, until the differences are

appreciated. In early plantings of the two trees, in Haiti and in Panama, *Siphonia* was reckoned as a complete failure, and the trees cut down, on account of the smaller flow of latex, before Ridley's method of repeated tapping of *Siphonia* became known. The secret lies in the latex tubes of *Siphonia* uniting into a network. The latex tubes of *Castilla* do not form a connected system, the flow of latex does not continue, and the *Castilla* trees are soon killed by severe tapping. Mechanical extraction is possible by harvesting the entire *Castilla* tree as a forest product, as explained in Science, April 23, 1937, but *Siphonia* is superior as a plantation tree, producing rubber in a few years and yielding regularly.

CONFUSION OF THE NAMES

The cultivated rubber tree is known to have been carried to the East Indies from the lower Amazon Valley, and often is called "the Para rubber tree," but is stated in many reference works to have been discovered in the forest of Esmeraldas on the Pacific coast of Ecuador by the French engineer-astronomer La Condamine in 1736. In reality, neither this tree nor any related species has been found in any locality west of the Andes, all the species of *Siphonia* being confined to the Amazon Valley or to the Atlantic watershed in Guiana and Venezuela.

The rubber tree of the Pacific coast district of Esmeraldas is a species of *Castilla*, like the Mexican and Central American rubber trees. The genus *Castilla* belongs to the breadfruit family, related to the fig and the Osage orange, while the Para rubber tree belongs to the spurge or euphorbia family, with the castor bean and cassava. *Castilla* is very widely distributed in tropical America, from Mexico to Brazil, had numerous uses among the natives, and furnished the early exports of rubber to Europe, not only from Mexico and Central America, but also from South America, including the Amazon Valley. The error of supposing that the Para rubber tree was discovered in Ecuador arises from the fact that the native name *heve*, relating in Ecuador to the *Castilla* tree, was carried to Guiana and erroneously used as the name of a genus, to which the Para rubber tree later was referred. The modern preponderance of the Brazilian rubber tree has left the error unrecognized.

La Condamine was the first European to foresee a commercial future for the strange elastic substance that others had passed as a curiosity. Two centuries earlier Sahagun had described the Mexican *ulli* as a very pliable resin (*resina muy correosa*) made into bouncing balls, and another century was to pass before Hancock and Goodyear

undertook its industrial development. La Condamine's interest in rubber was expressed in a report to the Royal Academy of Sciences at Paris in 1736, and led at Esmeraldas to a personal friendship with a capable young Spaniard named Maldonado, familiar with the native uses of rubber. Maldonado accompanied La Condamine on the return journey but died soon after reaching France, so that the rubber in Ecuador received no further attention.

Rubber was in demand, chiefly for candles and torches, and was being gathered in the upper Amazon Valley when La Condamine descended the river in 1743. Small objects modeled of rubber were seen at Para, and some of these were carried to French Guiana, where a search for rubber trees was started. Fresneau, an engineer who spent 14 years in this colony, found several latex-bearing trees, as reported through La Condamine to the Paris Academy in 1751. One of the Guiana trees was supposed from native information to be the kind that furnished rubber in Brazil, and this was described by Aublet in 1775 as *Hevea guianensis*. Several localities were noted, and the nuts were said to be gathered and eaten by the natives, the "almond" having a pleasant taste. La Condamine and Fresneau are not mentioned, but a reference is given to the "poor figure" of the Guiana tree in the memoir of 1751. The name *"Hevea peruviana"* engraved on Aublet's plate 335 leaves no doubt that the Guiana tree was supposed to be the same that La Condamine had found on the coast of Esmeraldas, "northwest of Quito," where *Castilla* grows, and the name *heve* was recorded.

Thus it came about that the name *heve*, used by the natives of Esmeraldas for the *Castilla* tree, was employed by Aublet as a generic designation for the Guiana rubber tree, and by later botanists it was extended to the Para rubber tree. Some writers have compromised by placing Esmeraldas in Brazil or in Venezuela, instead of in Ecuador, showing another kind of confusion that a misleading name may generate. Ducke says in a footnote of his *Revision of the Genus Hevea*, in 1935: "I do not know why Aublet attributed the origin of the name *heve* to Esmeraldas on the Pacific coast of Ecuador, where the genus Hevea is unknown." The reason is that the trees were assumed to be the same, since both produced rubber.

Aublet followed Plumier in using many native vernacular names as generic designations. Dozens of such names were adopted, some of them much alike and easily confused, as *Couepia, Coupoui, Couratari, Courbari, Couroupita, Coumarouna*, and *Coutoubea*. Linnaeus and his followers often rejected such vernacular names as "barbarous," but a

more serious objection may be seen in the lack of distinctive meaning, and the difficulty of remembering them as merely arbitrary collocations of letters or sounds. An authentic aboriginal name for an outstanding type, like *Mammea* for the mamey or mammee-apple of the West Indies, has meaning and historic interest, at least in its native country, but a misplaced aboriginal name, carried to a distant region and applied to a different plant, inevitably generates confusion.

SIPHONIA AN ALTERNATIVE NAME

To avoid the confusion thus inherent in the use of *Hevea* as a generic name for the cultivated rubber tree, the name *Siphonia* may be resumed, which had been the accepted name of the genus during three-quarters of a century and should have been retained. The return to *Hevea* by Mueller von Aargau in 1865 apparently was taken on grounds of priority alone, without considering that *Hevea* had been discarded as a homonym. The principle of priority, with its promise of greater stability in nomenclature, was coming into prominence in the time of Mueller, but priority alone is not a solution. It is only one of the principles that affect the utility of names. Under guise of priority many obscure names were taken up, which more careful study would have left in oblivion. The method of types, for fixing the original applications of generic names, received little attention from botanists until the last decade of the nineteenth century.

Specious arguments are made that rules of nomenclature should be set aside in dealing with names of important plants, to avoid troublesome changes. There is equal need to reflect that plants of special utility are more likely to receive historical study, and there is no assurance that "technical botany" will be appreciated for any special dispensations that would tend to confuse and obscure the early records. With the economic plants there is greater need of unequivocal names, not borrowed from other species. The taxonomic problems need to be studied with more care than has been customary, and with better appreciation of the various functions of botanical science in human welfare. Needless complications in codes of nomenclature are evidence of inadequate study. Our *International rules of botanical nomenclature* have a rather elaborate section on "Gender of Generic Names" but overlook an elementary rule of Latin grammar that has governed botanical usage, the rule that tree names and plant names take feminine adjectives, to agree with *arbor* or *herba* as an implied appositive.

The difficulties of changing names often are exaggerated, since

botanical workers are accustomed to the use of alternative names. The notion of new names being entered at once and old names summarily discarded, is found among indexers, cataloguers, or even herbarium assistants, rather than among experienced botanists, familiar with the use of names in the study of plants. The "old" names are not "wrong," unless they are given to the wrong plant. A familiar long-current name may continue for years to serve reference purposes, botanic, bibliographic, or commercial, better than a new name, unless both names can be given. The older names never are completely discarded, but remain in reference use among students of botany who have sufficient interest to follow the history of a plant to the original sources.

Changes of names necessarily are made gradually, since there is no escape under scientific methods from the fact that the acceptance of new names is determined eventually by knowledge of the plants. Like "patents applied for," new names obtain formal recognition when the descriptions are published, but general currency is not attained until other botanists have studied the plants and are convinced that the groups in reality are distinct from others previously known, or that the earlier names were not properly used. Practical tests of usage are not made unless suitable alternatives are available for names that are equivocal or confusing. A tree that has only an ambiguous, misleading name is less accessible to study.

Some of the changes of names result from new plants being discovered or mistakes corrected, while others arise from progress in classification through the discovery of new characters or relationships. It is a mistake to suppose that a completely uniform nomenclature is possible, or that a fixed system would be desirable in the present state of knowledge. All the names are provisional in the sense of requiring continued approval, and subject to change with increased knowledge. The notion of disregarding the names that were considered by their authors as provisional is one of the strange proposals in recent efforts to reform the system of nomenclature that would generate needless complications. In science as in other activities the tendency is for public interests to be treated casually, with the arguments often drifting away from the facts. The danger of science disintegrating into sterile specialties is not imaginary. Constructive reforms are needed to keep taxonomy as a part of the study of plants and to open this field of natural interest to a wider public. George Santayana's *Dialogues in Limbo* satirize botany as a trivial, overtechnical science with a peevish insistence on "the right names for flowers." ✓

RIDLEY'S FATEFUL DISCOVERY

A more fateful discovery than Ridley's method of harvesting the rubber of the *Siphonia* tree would be difficult to adduce from the pages of history. Many "epoch-making inventions" are recounted, but none that so promptly affected so many millions of people. In all civilized countries living conditions and social relations were profoundly changed in a few years. Even among primitive tribes in remote and backward regions of the Tropics, rubber cultivation had almost immediate effects. Thousand of Malays, Hindoos, and Chinese soon were engaged as contract laborers on the rubber plantations, while other thousands of even more primitive people were released from the gathering of wild rubber in forest regions of both hemispheres, and in effect were reprieved from extinction through Ridley's discovery.

A parallel may be seen in Eli Whitney's invention of the saw gin for short-staple cotton, which had social and political significance in the rapid expansion of Negro slavery in the Southern States, eventuating in the Civil War, but these effects were relatively local, while the rubber reactions are world-wide. The ascendancy of the northern nations of Europe may be ascribed to the introduction of the potato, but centuries were required for the potato sequence to work out, while less than half a century has elapsed since the first commercial planting of the *Siphonia* tree, in 1896.

To open new sources of rubber, the tropical world of both hemispheres was being ransacked before the first plantations began to produce. Hundreds of localized rubber-bearing plants had been found, trees, shrubs, and vines, and many of these were being intensively exploited, through natives enlisted as rubber-gatherers. Although commercial and industrial advantages are reckoned from such utilization of natural resources in primitive countries, the general effect is that the native populations are rapidly disorganized, depleted, and destroyed. The older rubber and chicle districts in southern Mexico and Central America were completely depopulated, and much of the rubber country in South America. Rubber-gatherers were recruited in the coast districts of Brazil and carried hundreds of miles to the rubber forests, where thousands perished. This period of frantic rubber-gathering reached an end when plantation rubber came into the market, and lower prices were in prospect. Gruesome chapters of exploitive savagery are outlined in the book entitled *Rubber, a story of glory and greed*, by Howard and Ralph Wolf, 1936.

Rubber production offered such immediate advantages that only a few years were required for a new agricultural industry to be created in the East Indies, and new manufacturing industries in Europe and America, providing new systems of communication and transportation in all civilized countries. Rubber and gutta-percha as insulating materials made it possible for electricity to be utilized. Our highly mechanized civilization often is symbolized as "the Rubber Age." Riding on rubber has become our "standard of living." A vast extension of the human environment has taken place.

Hundreds of chemical and physical discoveries have contributed to "modern scientific progress," but rubber in thousands of tons was necessary for the endless new applications to be developed. Ridley's biological observation was the critical point in quantity production, making it possible for our industrial and cultural transformations to go forward with such amazing speed. It might be said that Ridley turned on the rubber, and caused an industrial deluge. Even our "World Wars" and our "economic chaos" may be reckoned as consequences of Ridley's discovery, from facilities of transportation and communication being increased too rapidly for social adjustments to be made. Industrial populations "demand continuous prosperity" in order to furnish regular employment. Commercial rivalry is readily intensified to savage competition and national conflict.

RIDLEY A NATURALIST

It should not detract from our appreciation of Ridley's discovery that it was made under pioneer conditions and was not reported for several years, as Ridley explained in a letter to Fairchild, published in November, 1928, in the Journal of Heredity. Only a beginning was made, and scientific interest is not competitive. Ridley was not an inventor or an intensive specialist, but a naturalist, and the rubber tree with him was one of many concurrent interests. The tapping method was discovered casually, as a simple observation of latex flowing repeatedly from the same wound, and in larger quantity, after paring the cut.

It was known from Brazil that the first tapping drew little latex and was referred to as "calling the rubber." Hatchets were used for tapping in Brazil, gashing and scarring the trees, so that the surface in a few seasons became too rough for tapping to continue. The period of production would have been too short for plantations to have been practicable under the Brazilian method of tapping. Ridley's method replaced the many gashes with a single knife-cut, thus greatly reduc-

ing the labor of tapping, avoiding injury to the bark, and extending the period of production through many years.

Caring for the rubber trees at Singapore, as superintendent of the botanic gardens, did not make Ridley directly responsible for a study of methods of tapping. The extraction of rubber was viewed officially as a physiological problem and was being investigated at a laboratory in Ceylon. Notions of professional property might have kept Ridley's volunteer interest from being exercised. It was assumed in Ceylon that the Brazilian method of tapping with many small cuts would be followed, and on that basis there could be little outlook to commercial planting.

The theory of the wound response, as inducing a greater intensity of physiological action in the bark of the tree and thus increasing the flow of latex, has been reckoned as a scientific contribution from the work in Ceylon, but in reality it was erroneous and misleading. The underlying facts were determined by later investigators, that the latex system is continuous and that a more liquid latex, with a lower content of rubber, replenishes the tubes adjacent to the tapping cut, which explains the freer flow in the subsequent tappings. By virtue of the minute latex tubes uniting into a network, the entire system drains to a single outlet. The prompt replacement of the latex and renewal of the bark pressure may be viewed as a remarkable provision of the *Siphonia* tree against the wound reactions that otherwise might occur, if the tissues were depleted or were invaded by fungi or bacteria.

Novelty is not the naturalist's primary interest, nor is he intent upon the industrial or commercial utility of any fact that he may observe. The satisfactions of the naturalist are in seeing what nature affords. "I have never got over may astonishment at this world." Not only the lands and the landscapes, the towns and the belfries, call the naturalist, but all the forms of life, that he may "feast his heart." Bates, in *The naturalist on the Amazons*, recounts his years of unabated interest: "Although now a forest rambler of ten years' experience, the beautiful forest which surrounds this settlement gave me as much enjoyment as if I had only just landed for the first time in a tropical country." "The saddest hours I ever recollect to have spent" were in leaving Brazil. "I felt that the last link which connected me with the land of so many pleasing recollections was broken."

Ridley was an explorer of the Malayan forests, but he also took account of the South American rubber trees in the Singapore Garden and became interested in the flow of latex, to the extent of making his

simple tests. He wanted to see how close the cuts could be made together and whether the flow would be affected. Different cuts were tried and gradually simplified to a sloping groove cut with a sharp gouge, with a thin layer removed every morning or at intervals of two or three days, thus obtaining a repeated flow of latex, through weeks, months, and years.

THE FIRST COMMERCIAL PLANTING

Ridley saw the bearing of his discovery, but its practical importance still had to be demonstrated by establishing rubber plantations. As Lamarck once reflected, making a fact known often is more difficult than discovering it. Although many planters were "strongly advised to turn their attention to this plant," several years passed before any individual was found with sufficient intelligence and courage to make such an experiment on a commercial scale. Fairchild says, in *The world was my garden*, that Ridley "complained of the lack of interest the British planters of the Malay States showed in this Brazilian rubber tree." How many British planters refused the distinction of pioneering the rubber industry is not stated, but in 1896, according to Ridley's report, "Mr. Tan Chay Yan was induced by the Director of the Botanic Gardens to plant rubber." The discovery might easily have miscarried and been forgotten. An accident to Ridley or to Yan might have turned the scale. There was only this "Chinaman's chance" of rubber being planted. To Ridley it seemed in order that the Gardens be used and appreciated, but not that he should turn aside from botany and make a million out of rubber. "Reward as such has nothing to do with the essential act of creating."

False impressions are conveyed by much that is written to advocate science. Special states of mind are supposed to be needed for making important discoveries. "Scientific discovery almost always depends upon a man's looking at something in the dry light of the intellect and isolating himself from the previous thoughts both of himself and other men about it." Forced abstraction, "supreme attention to one thing," may be a mental environment for logical analysis of formal problems but is no substitute for the naturalist's interest. "No remarkable discovery is in the power of anyone." Ridley's discovery was an accident, but one that could not occur without the trees at hand, and the attentive mind.

Nobody at that time had the idea of a rubber tree with a continuous latex system, that would provide a repeated flow of rubber milk by shaving the margin of the same wound every day or on alternate days.

Such a notion of rubber production would have seemed too fantastic to be credited, until it took body as a fact, after Ridley's discovery and demonstration. Goethe says that we see only what we know, but with each advance of knowledge somebody must see what has not been known, or even expected. This is the creative vision, to see things as they actually are, and to lay aside our former limitations. The expansion of the rubber industry, after the first plantation had succeeded, was so immediate and overwhelming that Ridley's discovery was generally overlooked and might have remained in oblivion if Fairchild's record had not been published.

The need for naturalists now seems greater than ever, on account of our present civilization being so badly overbalanced on the mechanical and industrial sides, even in the study of the biological sciences. Researches may be conducted in formal lines and elaborately recorded by men who are not naturalists, take little notice of outlying facts, and frame their structures of knowledge as closed systems. A misleading emphasis often is placed on logical or statistical analysis of facts that have been reduced to formal records, but without the naturalist's interest in the wider relations. The nature and extent of Ridley's interest may be followed in his many papers and books on the flora of the Malay region and in his massive work on *The dispersal of plants throughout the world*, published in 1930, a general treatise on the adaptive characters that determine the dissemination of plants. A review of his botanical work appeared in Nature for March 21, 1936, occasioned by his eightieth birthday, December 10, 1935.

Sending the tree abroad to let naturalists study it doubtless would have seemed a fantastic proposal. Progress is contingent on bringing the naturalists and the trees together. Brazil and other neighboring regions may be advantaged in the end from the knowledge obtained in foreign countries. Several eminent naturalists, as Martius, Wallace, Bates, and Spruce, spent many years in Brazil, but there the rubber trees are immersed with thousands of other species in the vast Amazonian forest, and detailed study is out of the question. Not until the trees are grown separately do their characters and habits become known. Even botanical specimens of the forest trees are seldom obtained, except as a good marksman may shoot down twigs or small branches with a rifle. The forest canopy of the tropical world is less explored than the polar ice-caps. Doubtless some botanical Byrd will rig a dirigible with a barge of canvas or wire netting that will rest on the roof of the forest and allow the treetops to be visited.

The chief discovery in South America regarding *Siphonia* is the

leaf disease caused by the fungus *Dothidella ulei*, or *Melanopsammopsis ulei*. This disease is a serious obstacle to open planting of *Siphonia* in Brazil, on account of many fatalities in the seedlings and juvenile stages, but Ridley's method of tapping is being applied to trees of natural growth in the forests, and systems of permanent production may be developed, instead of rubber districts producing for only a few years. Commercial interests suffered when the sending of rubber-gatherers into the remote forests became unprofitable, but with regular production of rubber settled populations may be established in many of the rubber districts, and Brazil again may become the principal source of rubber.

OTHER VERNACULAR NAMES

The primitive people who inhabited the forested regions of tropical America lived in small, widely separated groups, each tribe with its own language and with different names for most of the natural products. The rubber of the *Castilla* tree had the name *cauchuc* in the language of the Incas, now called Quichua. The French spelling is *caoutchouc*, and the modern Spanish form is *caucho*, the word that still is used as the name of *Castilla* rubber, not only in Ecuador and Peru, but also in Brazil. *Castilla* as well as *Siphonia* existed in all the rubber areas of the Amazon Valley, and caucho rubber still is exported in commercial quantities, especially where new districts are being opened.

The name *caucho* is not applied in South America to the rubber of the *Siphonia* tree, but a Portuguese name *borracha*, meaning *bottle* in the original sense of a leather wine-skin. Some of the tribes along the Amazon knew how to make bottles and squirt-guns by spreading the latex over an earthen mold, curing the rubber in the smoke of palm-nuts, then crumbling and washing out the earthen material. Some writers have supposed that the *Siphonia* tree was called *syringa* by the Portuguese colonists because syringes as well as bottles were made of the latex, but a simpler explanation may be that the flowers are clustered like lilacs and have the same fragrance. The men who gather the *Siphonia* rubber are called *seringueiros*, while the *caucheros* are those who collect the *Castilla* rubber, a different occupation.

The Aztec name for *Castilla* rubber, *ule* or *hule*, was recorded by a Spanish historian, Sahagun, who arrived in Mexico in 1529, more than two centuries before La Condamine reached South America. In the seventeenth century another Spanish writer, Cobo, recorded the Peruvian name *cauchuc*, and identified it with the *ule* of Mexico,

"which is well known in all the Indies." The leaves, branches, and fruits of the tree are described to an extent that leaves no doubt of it being *Castilla*. Cobo's book, *Historia del Mundo Nuevo*, written in 1653, was published in Seville in 1891. No warrant has been found for a statement in a recent textbook of economic botany that the name *cahuchu* was derived from "primitive Central American Indians." Many other names, as *sheve, sabac, sabbe, zini, sini,* and *seru,* are recorded in Lehmann's *Zentral Amerika* as equivalents of *ule* or *caucho* in native languages of Ecuador, Colombia, Panama, Costa Rica, and Nicaragua. The *tunu* or bark-cloth tree of the Mosquito coast is a species of *Castilla*, said to produce only inferior rubber.

Rubber from some of the "West coast" districts still is called *jebe* as a trade name. The word is defined in several Spanish dictionaries as *caucho* or *goma elastica*, indicating that the two words were separately adopted from different native languages of "Peru" in the colonial period. At the beginning of the nineteenth century Humboldt and Bonpland reported the name *caoutchouc* as associated in Colombia with two species of *Ficus*, and with a species of *Lobelia* growing as a tree 20 to 30 feet tall, at altitudes of 6,000 to 9,000 feet, in the mountains around Popayan.

TREATMENT OF HOMONYMS

The name *Siphonia* was substituted for *Hevea* by Lamarck on plate 790 of the *Encyclopédie*, but the illustrations did not appear till 1798, The change was noted in the second volume of the Supplement. published in 1812, but the volume with *Siphonia* in alphabetic sequence was delayed to 1817. The publication of *Siphonia* usually is dated from Schreber's *Genera plantarum*, 1791, where the name is credited to Richard, who probably suggested it to Lamarck. Willdenow, in 1805, seems to have been the first author to publish a species under *Siphonia*, with Richard as the author of the specific name, *Siphonia cahuchu*, and *Hevea guianensis* Aublet as a synonym.

Another generic substitute, *Caoutchoua*, was proposed by Gmelin in the same year with Schrader's publication of *Siphonia*, 1791, and was accompanied by a specific name, *Caoutchoua elastica*. Thus *Caoutchoua* appears as technically established 14 years before *Siphonia* was equipped with a species by Willdenow. Rules of nomenclature, strictly interpreted, would require this name *Coautchoua* to be used, with the type species as *Caoutchoua guianensis* (Aublet), a new combination.

The underlying objection to *Caoutchoua* being accepted instead of

Siphonia is the same as against *Hevea*—the confusion inherent in the fact that the vernacular name *cauchuc* or *caoutchouc* related originally to the *Castilla* tree and was not properly available as a name for the *Siphonia* tree of the Amazon Valley. Misplacement of vernacular names in scientific terminology obviously is unwarranted, and doubtless will be condemned in codes of nomenclature. If botany stood entirely alone, arbitrary borrowing of vernacular names conceivably might be tolerated, but for botanical terminology to remain permanently at variance with the neighboring sciences, as philology, ethnology, and pharmacology, is scarcely thinkable.

Formerly it was considered that homonyms might be revived where the earlier use of a name had proved invalid. Thus in DeCandolle's *Prodromus* the name *Evea* Aublet was placed as a synonym of *Cephalaeis*, and this may have been supposed to allow the revival of *Hevea*, but later writers have treated *Evea* as a distinct genus. The instability of names resulting from such variations of opinion among taxonomists resulted in the rule against homonyms being revived, after once being discarded. There is nothing to indicate that Mueller took account of the early history of *Hevea* or of the objection to homonyms being restored.

If the names are not words to be spoken, but only graphic symbols to be copied on labels and catalogue cards, the difference of a silent letter may seem sufficient, since it gives a visible difference, if not vocable. The earlier botanists undoubtedly thought of speaking the names, so that homonyms quite definitely included homophones. Thus it is possible to object that the names were not identical, and that substitution of *Siphonia* for *Hevea* was not warranted, but the fact remains that the change actually was made and was generally adopted, and that such rejections of names have been considered as irreversible, under rules of nomenclature. "Once a homonym always a synonym." No object is gained by going back to a doubtful or debatable name, once it has been challenged and discarded as causing confusion. Treating one name as dependent on variable opinion regarding the availability of another name obviously conflicts with the primary need of stability in nomenclature.

MISLEADING NAMES FOR THE SPECIES

The name *brasiliensis*, generally associated with the cultivated rubber tree, was borrowed from a related species, not found in the lower Amazon Valley but on the southern frontier of Venezuela, along the streams that connect the head waters of the Orinoco and the Rio

Negro, a region explored in 1800 by Humboldt and Bonpland. The description of the tree was published by Humboldt, Bonpland, and Kunth under the name *Siphonia brasiliensis* in 1825, in the last volume of the monumental work on the plants of Humboldt's travels in tropical America, *Nova genera et species plantarum* 7: 170. Two localities were reported and two native names, *jacio* for the tree and *dapiche* for the white rubber, "*caoutchouc album*," said to adhere to the roots, presumably as exposed on the banks of the rivers. Pittier has *jacia* as a native name in Venezuela, but not *dapiche*.

The name *brasiliensis* seems to have been occasioned by the Humboldt specimen being compared by Kunth with a specimen in the Willdenow herbarium, to which the name *Siphonia brasiliensis* had been attached, but without being published. It is hardly to be maintained that the use of this name by Kunth constituted a publication of the Willdenow species. A name is not authenticated by being mentioned in synonymy or by being printed with a description of a different species. Instead of basing his description on the Willdenow plant, Kunth stated in a footnote that the Willdenow specimen had smaller leaves, paler underneath.

The normal assumption would be that the name belongs to the Humboldt species, the association that is recognized in the *Index Kewensis* and other reference works. Since Brazil at that time was a geographic expression rather than a political entity, the name *brasiliensis* would not have appeared inappropriate for any tree from the vast central forest of South America. The proposal of Baillon in 1858 that the Humboldt tree be assigned a different name, *Siphonia kunthiana*, would avoid for this species the confusion involved in the name *brasiliensis*, but for the cultivated rubber tree the name *brasiliensis* would still be ambiguous, leading back inevitably to the Humboldt rubber tree and to the long confusion of the two species. Lamarck recognized in 1789 that the rubber tree of the lower Amazon was different from Aublet's Guiana species, but the Humboldt tree was accepted by many writers as the source of commercial rubber. Even in Mueller's critical revisions of the group in DeCandolle's *Prodromus*, 1866, and *Flora Brasiliensis*, 1874, the two species were not separated, Baillon's *Siphonia kunthiana* being placed as a synonym of "*Hevea brasiliensis* Muell. Arg." No specimens of the fruits or the seeds were seen by Mueller.

Owing doubtless to the confusion of the two species, no detailed account of the lower Amazon rubber tree was furnished, but in 1874 a description was drawn from specimens grown at Rio Janeiro, which

Mueller did not recognize as the Para rubber tree, and published as a new species under the name *Hevea janeirensis*. This name may be transferred to *Siphonia* as a new combination, *Siphonia janeirensis*, but using this name for the cultivated rubber tree would create more confusion, as if a Florida plant that happened to be grown in Canada were named *canadensis*. The case is parallel to the use of *Asclepias syriaca* as the name of our New England milkweed, and *Simmondsia chinensis* for the jojoba nut of southern California and Arizona, plants not native in Syria or in China or having any relation to those countries except as specimens were wrongly labeled. The use of such names, admittedly erroneous and misleading, marks a phase of professionalism among herbarium workers that doubtless will prove temporary.

For filing pressed specimens in herbaria, one name may serve as well as another, but in field and garden studies these misleading names are a permanent handicap, requiring always to be "corrected" and explained anew to each generation of botanists and plantsmen. If the name *Siphonia janeirensis* were used, all future generations of botanists and writers on rubber would need to be cautioned and checked against the natural assumption of a native rubber tree at Rio Janeiro in southern Brazil, hundreds of miles beyond the natural range of distribution of the species, or of other members of the genus. The name in itself is of little moment, but avoiding confusion is important. In writing *Siphonia ridleyana* we acknowledge our debt to Ridley and also admit the need of more care in naming plants.

A RIVERINE HYBRID

An extreme variability of the cultivated rubber tree may be connected with the biological status of the wild stock in South America. Because of the geographic position of the species in the lower Amazon Valley and the adaptation of the seeds for floating, unusual conditions for hybridization are afforded, not as a rare contingency but as a normal occurrence. Swollen currents from the upper river often reverse the flow of the lower tributaries, so that floating seeds may be stranded far from the main channel. Thus the stock of *Siphonia* over a wide area of the lower valley must have remained continually accessible to crossing with the several up-river species. Hybridizing as a preliminary to selection has been accomplished in nature.

The range of variation in *Siphonia ridleyana* may be found to include all the characters of the other species, when these are definitely known, and with endless abnormalities appearing among the seed-

lings, beyond the range of the parental types, comparable to the extra-parental diversities shown in perjugate hybrids between different species of cotton, as described and illustrated in the Journal of Heredity for February, 1915. The same problem is presented, of finding among the infinite wrack of degenerating forms any lines of descent with desirable characters in stable patterns, "coming true" from seed. High-yielding types are being utilized by budding, but are only a partial solution of the trading problem. Uniform seed-stocks would be much more valuable. Comparing progenies of tree-crops in order to determine uniformity is an experimental undertaking of vast proportions, in which all the rubber-growing countries might well cooperate.

The diversity in the cultivated stock of *Siphonia* is comparable with that of some of our animals and plants that have been domesticated for long periods, as cattle, horses, dogs, wheat, cucurbits, and potatoes. The range of characters in these long-domesticated groups is supposed not to have been derived from a single wild stock but from several related species developed in different regions, but brought together and mongrelized in primitive times. Diversity is found among the members of all the wild species of plants and of animals that are studied carefully, but usually the diversity is less than in the cultivated stock of *Siphonia*. Other species are considered in Ducke's *Revision* to be as variable as "*brasiliensis*," and this would be expected of any stocks similarly exposed to crossing.

The trees are found to differ not only in the stature and growth of the trees, the leaves, floral characters, and seeds, but also in the bark texture and in the latex tubes, which determine the yield of rubber. The surface of the bark may be smooth or finely wrinkled like a beech tree, or rough and rimose like an elm or an oak, while the texture may be uniform, soft and cheesy, or brittle and gritty with stone-cells. Records show some trees yielding scarcely any rubber, and others only small amounts, with a few far above the general average, so that 75 per cent of the rubber is produced by 15 to 25 per cent of the trees. Budding from high-yielding trees raises the average, although yields vary as before, on account of diversity of the stocks.

To exhibit the diversity of leaf-forms many illustrations would be required. A single example is given in Fig. 1, showing in natural size two slender leaves from an abnormal plant, compared with a normal leaf. The closer and more numerous primary veins of the abnormal pinnae should be noted, as well as the narrow outlines and crenate margins. Many variations have still narrower pinnae, and the margins notched to the midrib, while others have curved or twisted pinnae,
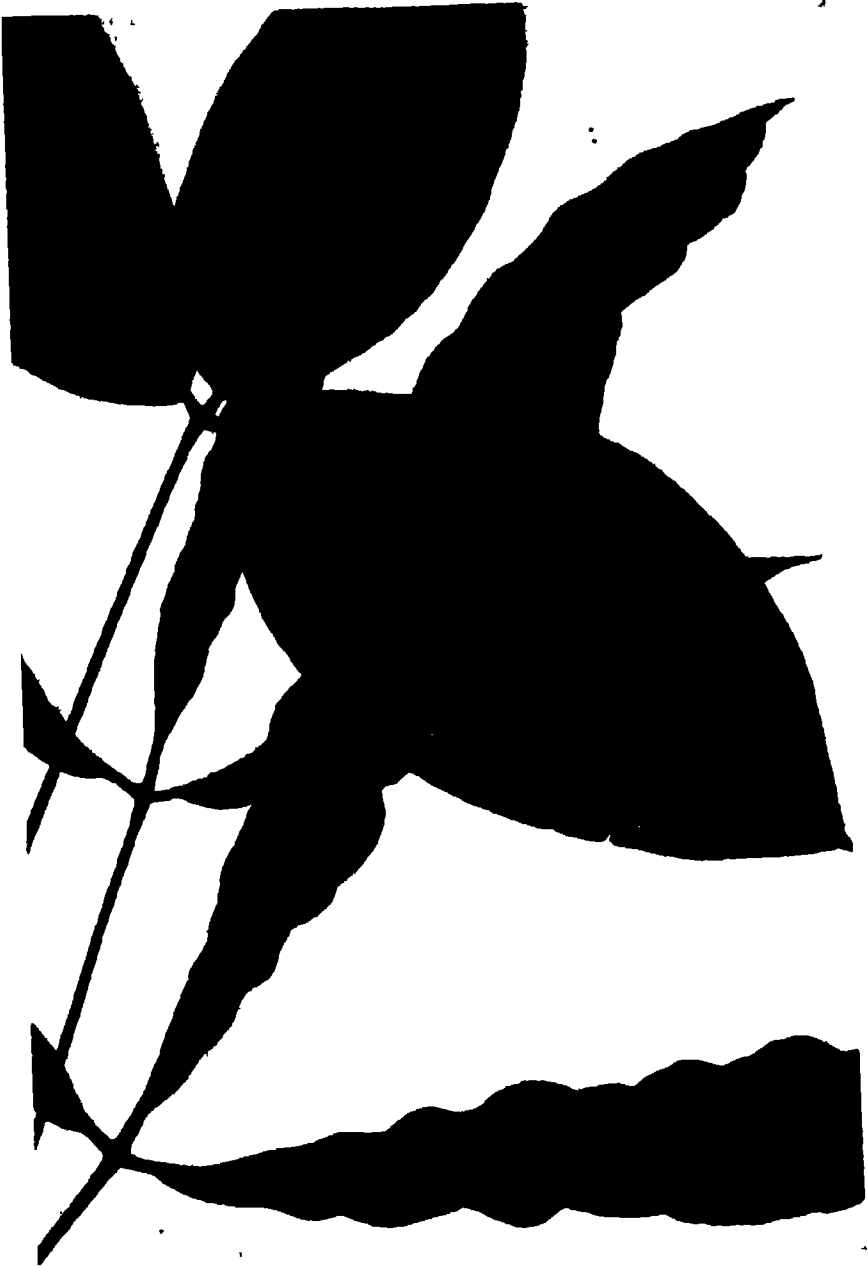
Fig. 1.—*Siphonia ridleyana*, a normal leaf overlain by two abnormal leaves. Natural size.

or funnel-shaped "ascidia." The series of foliar aberrations is comparable to that of the familiar "crotons" or codiaeums, which also belong to the spurge family.

Pinnae of normal form are only two or three times as long as wide, while some of the abnormal pinnae are 10 times as long as wide, or even 20 times as long. Most of the extreme mutants are outgrown by the normal plants and smothered in the seedbeds, or not transplanted from the nurseries, but a mature narrow-leaved tree, with flowers and fruit, was found in Haiti. The pinnae were slender and tapering, similar to those of the photograph, though not elongate. Some abnormal plants have the stalks of the pinnae longer than usual, or the stalks may be very short and grown together, so that the pinnae do not separate. Leaves with supernumerary pinnae, 4, 5, or 6, are found on trees otherwise normal.

Heavier texture of the foliage may be a factor of resistance to the South American leaf disease, and earlier attainment of the adult foliage is a character to be regarded in selection. Plantations of *Siphonia* are difficult to establish in Brazil and other American countries infested with the leaf disease because many young trees are defoliated and killed. The juvenile stage is specialized, the branches suppressed and the foliage more delicate, adapted to shade conditions in the undergrowth of the forest, as explained in Science.[3]

SIPHONIA ADAPTED TO SMALL FARMING

The system of large plantations operated by contract labor, as practiced in the oriental countries, may not be feasible in tropical America, but other modes of production may be developed that do not require large undertakings. The momentum of a vast industry makes it difficult to think of planting trees in hundreds instead of thousands. In reality the *Siphonia* tree, under the Ridley method of tapping, is as well suited to small independent producers as to large estates, thus avoiding the "overhead" expenses that often absorb more than half the outlay in opening plantations. All the tropical American countries are users of rubber, and all may become regular producers. First efforts in new districts may fail because the seeds are short-lived and the seedlings rather delicate, but once the trees are established they are likely to become a permanent resource. Where beginnings are assisted and seeds or budded stocks are available, the trees can be grown among other crops with little labor or expense, merely replac-

[3] Science 71: 386–387. 1930.

ing some of the nonproductive trees that often serve in tropical gardens or orchards for shade or wind protection.

Castilla often has been used as a shade tree, but a regular yield of rubber is not obtainable. Because the *Castilla* latex flows freely at the first tapping, there is much more danger of the rubber being stolen and the trees killed or permanently injured by marauders. More labor is required to harvest the rubber of *Siphonia*, but production is regular. Even a hundred *Siphonia* trees, the planting quota of a single acre, may engage the interest of self-supporting families in all the countries where the tropical tree-crops are grown, notably coffee and cacao, where avocados, papayas, guavas, or citrus fruits are grown, as in southern Florida. The rubber trees would be tapped every second or third day, requiring an hour of labor and affording a return of a dollar or more from each hundred trees. The work is light and clean and is done in the cool of the morning.

Experiments in southern Florida, near Coconut Grove, indicate that *Siphonia* and other tropical rubber trees, as *Castilla*, *Funtumia*, and *Manihot*, are adapted to the local conditions, flowering and seeding abundantly. Rubber produced by *Siphonia* trees in Florida has been tested by the National Bureau of Standards, and excellent quality found. Popular interest may lead to general planting of *Siphonia* and the other rubber-bearing types in southern Florida, at least as garden trees, and with fresh latex at hand new uses of rubber or improved manufacturing processes may be worked out. The stocks may be improved by selective breeding and through survival of the hardier trees in periods of unusual cold. Hardier strains developed in Florida might be of use in Mexico and in many other countries. The extent of tolerance of low temperatures or other unfavorable conditions is still to be determined. Apart from any question of producing commercial quantities of rubber in Florida, the information and experience that would be gained by planting rubber trees in different localities in Florida might be of great value in extending the range of rubber planting among resident populations in tropical America.

The limitation of the genus *Siphonia* to the Amazon Valley and the eastern slopes of the Andes carries no implication that planted trees will not thrive in the Pacific belt of Ecuador and Colombia and in other parts of tropical America, as they have in Asia and Africa. The natural distribution of the South American leaf disease is still unknown. It has not been found in Haiti or in Florida, and it may be absent from other islands or parts of the mainland, although it has appeared in Dutch Guiana, Trinidad, and Costa Rica.

HERPETOLOGY.—*A critical synopsis of the Mexican lizards of the Uta ornata complex and a description of a new species from Chihuahua.*[1]   M. B. MITTLEMAN, Ohio University, Athens, Ohio. (Communicated by LEONHARD STEJNEGER.)

Since Schmidt (1921) published his brief paper containing diagnoses of new forms and a key to the entire genus, no one paper has appeared dealing with the Utas as a cohesive whole, or in entirety. Neither has any paper dealt with all the forms within any one group of the genus. Smith (1935) published the description of a new species (*Uta caerulea*) from Mexico and included in his paper some notes on certain other Mexican Utas, which up to that time had been largely neglected in the literature. In his lengthy work on the reptiles of western North America, Van Denburgh (1922) treated only those forms coming within the scope of his studies, namely, the species and subspecies occurring in the United States, extreme northern Mexico, Baja California, and the islands within the Gulf of California. The notes and diagnoses herein deal with the Mexican representatives of the *Uta ornata* complex and are offered until a longer paper dealing with the entire complex is published.[2]

Uta ornata lateralis Boulenger   Figs. 1A, 2

Uta (Phymatolepis) lateralis Boulenger, Ann Mag Nat. Hist (ser. 5) 11: 342 1883.

Type locality.—Tres Marias Islands and Presidio de Mazatlán, Sinaloa

Cotypes.—BMNH 81.10 91–4 and 82 12 5 2

Diagnosis.—One to three vertebral rows of enlarged, imbricate, carinated, irregularly arranged scales, extending from the nape of the neck onto the base of the tail for a distance equal to slightly more than half the length of the femur; bordered on either side by one, and then two series of enlarged, prominently carinated, imbricate, regularly arranged scales, those of the inner series being approximately twice as large or larger, than those of the outer series; largest of the dorsal scales superior in size to the largest of the enlarged, carinated scales of the femur and tibia; two or three elongated series of thoracic tubercles, a dorsolateral series of enlarged, mucronate, and tubercular scales, extending from the supra-axillary or thoracic region to the

Fig. 1.—Characteristic enlarged dorsal scales of the several Mexican species of the *Uta ornata* complex: A, *Uta ornata lateralis* Boulenger, topotype, M C Z no. 22467, male, María Magdalena Island, Mexico B, *Uta clarionensis* Townsend, type, U S N M. no. 15904, male, Clarion Island, Revillagigedo Archipelago, Mexico. C, *Uta unica*, sp nov, type, U S N.M. no 14248, female, Chihuahua, Mexico. D. *Uta bi-carinata tuberculata* Schmidt, M C Z. no. 37854, male, Guirocabo, 20 miles southeast of Alamos, Sonora, Mexico. E, *Uta auriculata* Cope, type, U S N M. no 7027, female, Socorro Island, Revillagigedo Archipelago, Mexico F, *Uta bi-carinata anonymorpha* Mittleman, type, U S.N.M. no. 46888, male, Tehuantepec, Oaxaca, Mexico G, *Uta bi-carinata bi-carinata* (Duméril), U S.N.M. no 20180, male, Cuernavaca, Morelos, Mexico H, *Uta bi-carinata nelsoni* Schmidt, type, U S.N.M. no. 46836, male, Cuicatlán, Oaxaca, Mexico

Fig 2.—Distribution of the *Uta ornata* complex in Mexico

basal portion of the tail; several lateral series of enlarged, granular, spinose scales; ventrals abruptly differentiated from the scales of the lateral areas; scales of belly and gular region strongly imbricate and submucronate; frontal typically divided transversely; a postfemoral dermal pocket regularly present Coloration (alcoholic male topotype): A series of six to nine dark spots on the dorsolateral line extending from axilla to groin; a vertebral series of smaller, alternating spots extending from the nape to the basal portion of the tail; dorsolateral and vertebral spots of both sides usually joined by undulating light brown bands, which are occasionally broken medially; general dorsal coloration of body and limbs light gray or brown, or occasionally a uniformly rufescent dark brown which completely obliterates any semblance of pattern; limbs barred above with dark brown; dorsum of tail similar to dorsum of body, and lightly ringed with pale brown; lateral areas a light blue-gray, irregularly streaked with brown; abdomen with two elongate, light blue patches which may or may not be fused medially; rostral and supralabials white, this color extending posteriorly in a narrow streak to the insertion of the fore limbs; infralabials flecked with gray; gular region anterior to the fold, light blue; underside of limbs, tail, interhumeral and interfemoral areas, whitish. Measurements of fifty adults, both sexes, insular and mainland: Snout to posterior border of ear, 12.6 mm; head width, 9.6 mm; snout to vent, 49.5 mm; hind leg (insertion to tip of 4th toe, exclusive of nail), 35.90 (these figures represent the weighted arithmetic means).

Distribution.—Tres Marias Islands; Tiburon Island; Sinaloa (Boulenger, *loc. cit.*); Sonora, south of the line Caborca–Magdalena.

Remarks.—Although my findings concerning the intergradation of *lateralis* and *linearis* (of southern Arizona) agree in substance with those of Van Denburgh (1922, p. 199), I have not been able to detect any signs of that intergradation in several hundred specimens from extreme southern Arizona as he did. I find, rather, that this intergradation occurs in the belt bordered on the north by the line Reforma–Cananea, and on the south by the line Caborca–Magdalena. Quite typical *lateralis* are taken regularly south of the Caborca–Magdalena line. Boulenger's record (*loc. cit.*) for the subspecies from Presidio de Mazatlan, Sinaloa, may be open to question on the grounds that Taylor and Smith, as well as other workers have failed to take any additional specimens of this form from that locality, while related species have been taken in the vicinity. Indeed, *lateralis* is known from no state except Sonora; extensive field studies should reveal this lizard in northern Sinaloa, at least

Comparisons made between large series of insular and mainland specimens reveal only slight mensural differences, which are neither constant nor marked enough to warrant a subspecific distinction being made between the two populations.

U. o. lateralis may be quite easily separated from *linearis* on several scores. In the former, the enlarged dorsals commence well craniad of a line joining the anterior points of insertion of the fore limbs; in the latter race, these commence either slightly craniad of a line such as this, or else distinctly caudad of it. In *lateralis* the scales of the inner series of enlarged dorsals are

at least twice the size of the scales of the outer series; *lateralis* also possesses
a prominent dorsolateral series of spots. *U. o. linearis* possesses no regular,
distinct series of dorsolateral spots, nor is there a very appreciable difference
in size between the scales of the outer and inner series of enlarged dorsals.

Uta auriculata Cope   Figs. 1C, 2

Uta auriculata Cope, Proc. Boston Soc. Nat. Hist., 14: 303. 1871.
  Type locality.—Socorro Island, Revillagigedo Archipelago
  Type.—U. S N. M. no. 7027.
  Diagnosis.—Unique among the members of the *ornata* complex in possess-
ing the enlarged femoral scales uncarinated; two vertebral rows of small,
enlarged scales, these weakly carinated, imbricate, and fairly regularly dis-
posed; bordered on each side by a single series of enlarged, imbricate, weakly
carinated, rather flat scales, which are about twice as large as those of the
vertebral series; a few scattered, slightly enlarged scales on the dorsolateral
line; frontal transversely divided; postfemoral dermal pocket probably pres-
ent (type in too poor a condition to accurately determine this); general ap-
pearance not all rugose. Cope (*loc cit*) describes *auriculata* as having a row
of spots on the dorsolateral line, on a blue ground color. Measurements of
type: Snout to posterior border of ear, 17 0 mm; head width, 11 5 mm; snout
to anus, 75 0 mm; hind leg (insertion to tip of 4th toe, exclusive of nail,
49 mm.
  Distribution —Restricted to the type locality.

  Remarks —Of this species, I have examined only the type specimen. As
far as this specimen goes, it is quite distinct from other known members
of the genus

Uta clarionensis Townsend   Figs. 1B, 2

Uta clarionensis Townsend, Proc. U. S Nat. Mus 13: 143.   1890
  Type locality —Clarion Island, Revillagigedo Archipelago
  Type.—U. S N M no 15904.
  Diagnosis.—Enlarged vertebral scales distinctly carinated, in two irregu-
lar series commencing on the nape of the neck and extending posteriorly onto
the base of the tail for a short distance; bordered on either side by two series
of enlarged, strongly carinated, imbricate scales, which are larger than the
vertebrals, and of which the scales of the outer series are smaller than those
of the inner series; scales on thighs enlarged and prominently carinated;
dorsolateral tubercles and spinose scales well developed, and in clusters,
forming an almost unbroken ridge; frontal transversely divided; postfemoral
dermal pocket absent. Measurements of type: Snout to anus, 53 mm; hind
leg (insertion to tip of 4th toe, exclusive of nail), 41.0 mm; snout to posterior
border of ear, 14 0 mm, head width, 10.0 mm.
  Distribution —Restricted to the type locality.

  Remarks.—Because of its closer affinity to *lateralis* than to the neighboring
auriculata, *clarionensis* presents several important and interesting phylo-
genetic features. These will be later discussed under the phylogeny of the
several forms.

Uta bi-carinata bi-carinata (Duméril)   Figs. 1F, 2

Phymatolepis bi-carinatus Duméril, Arch. Mus Hist. Nat Paris **8**: 549, pl. 23, figs. 2, 2a, 2b.   1856.   .

Type locality.—"Mexico."

Type.—Not designated; if in existence, probably in the Muséum d'Histoire Naturelle de Paris.

Diagnosis.—Two or three vertebral series of enlarged, imbricate, weakly to prominently carinated scales, extending in a continuous or a broken line from the nape of the neck or the shoulders to the basal portion of tail, on which it continues for a distance subequal to the length of the femur; external to the vertebral series and bordering them on each side, is a single series of greatly enlarged, strongly carinated, imbricate scales which are occasionally unequal in size, irregular of arrangement, and frequently interrupted; the largest of the dorsal scales smaller than the largest of the femoral and tibial scales, which are imbricate and strongly carinated; external to the enlarged dorsals, which border the vertebrals, there is on each side a series of enlarged scales almost equaling them in size and rugosity; these sometimes in contact with the enlarged dorsals, but more often separated by two to four of the granular, convex scales of the back; these enlarged scales are also irregular in size and disposition, often commencing anterior to the enlarged dorsals; two or three enlongated series of enlarged tubercles on the neck; a prominent series of enlarged, spinose scales on the dorsolateral line, and ventral to these are four more, somewhat less prominent series, the lowest of which is in contact with the ventrals; ventrals mucronate, and occasionally somewhat spinose; as they progress laterally there is a slight tendency towards carination, which becomes most noticeable in the lateral scales, scales of the chin granular and pavemented medially and laterally; elongated, flattened, spinose and imbricate posteriorly; frontal variable, but most often entire, a postfemoral dermal pocket usually absent, but sometimes rudimentarily present. Coloration (alcoholic male): Grayish ground color on dorsum of body, head, limbs and tail; body dorsum with four or five dark cross bands, which may or may not be visible, due to an occasional suffusion of dark pigment throughout the skin, these bands often being broken medially; entire forsum of body and limbs often flecked with dark gray, pale gray, or brown; lateral areas of body usually similar in color to dorsum, but more often tinted with a bluish wash; venter of limbs, interhumeral and interfemoral areas, of varying shades of gray, and often heavily mottled with brown; ventrally, the basal portion of the tail a light gray, occasionally spotted with dark brown; a broad blue patch on the belly, which is slightly more intense anteriorly, and which may or may not be overlaid with a heavy stippling of gray or brown; except for an occasionally light medial area, the entire chin, including the infralabials, is heavily mottled with black or brown. Smith (1935, p 170), reporting on freshly collected specimens says "the entire gular region is orange, coarsely reticulated or diagonally barred with black except in a large, round median area just anterior to the gular fold." Measurements of fifty adults, both sexes: Snout to posterior edge of the ear, 12.5 mm; head width, 10.6 mm; snout to anus, 52 5 mm; hind leg (insertion to tip of 4th toe, exclusive of nail), 29.6 mm (these figures represent the weighted arithmetic means).

Distribution.—Michoacán, Morelos, Puebla, and Guerrero west of Acapulco.

Remarks.—Much of the confusion surrounding the status of this form is

undoubtedly due to the fact that Duméril designated simply "Mexico" as
the type locality for his species, and this only through inference Conse-
quently, the several authors who have had occasion to deal with *bi-carinata*
and its affiliates, especially prior to the separation by Schmidt (1921) of the
then composite species, have cluttered the literature with erroneous locality
records based on misidentified specimens. Both Schmidt (*op cit*) and Smith
(1935) have contributed to the clarification of the status of *bi-carinata*, and
to these authors credit is largely due for bringing a measure of order to the
state of chaos

The Utas from the southern periphery of the range of *bi-carinata*, notably
from a point just southeast of Acapulco and extending through Guerrero to
Tierra Colorada, exhibit certain tendencies which are not in accord with the
attributes to be noted in more northerly examples As the population con-
tinues in the direction of the Oaxacan border this trend becomes more no-
ticeable, so that in eastern Guerrero and Oaxaca, the lizards can no longer
be considered identical with their more northerly relatives, and clearly
possess the status of a separate biological entity Since the population from
Michoacan, Puebla, Morelos, and western Guerrero more closely fits the
original description than does the southern form, I have retained the name
bi-carinata for it, and described the southern population as a distinct sub-
species

Uta bi-carinata anonymorpha Mittleman   Figs 1G, 2

Uta anonymorpha Mittleman, Herpetologica II, 2: 34, pl. 3, fig. 2 1940.
Type locality —Tehuantepec, Oaxaca
Type.—U. S. N. M. no. 46988.
Diagnosis.—Enlarged vertebral series of scales and the scales external to
them, which are larger in size, commencing on the shoulders only slightly
craniad of a line joining the anterior points of insertion of the fore limbs; en-
larged dorsals in a continuous series or but barely encroached upon by a few
of the small, granular scales of the back; enlarged dorsals regularly arranged
and not too strongly carinated; external to the enlarged dorsals is a sparse
series of enlarged scales, a trifle larger in size than the scales of the vertebral
series, but never approaching size the larger enlarged dorsals; this outermost
series of enlarged scales never in contact with the primary series of enlarged
scales, but in contact at several points with the rather sparse and poorly
developed tubercular and submucronate scales of the dorsolateral line
through the medium of small, elongated clusters of slightly enlarged, granu-
lar scales; thoracic tubercles not well developed and not too prominent;
dorsolateral and lateral tubercles often not well developed, and often not in
clusters, but consisting rather of a single enlarged, spinose, tubercular scale
surrounded by two or three somewhat enlarged, mucronate scales; ventrals
mucronate and spinose, especially posteriorly; laterally these become dis-
tinctly carinated and quite prominently pavemented; scales of the chin
small, rather flat, and generally pavemented, only those scales immediately
anterior to the gular fold becoming elongated, imbricate, and somewhat
spinose; general appearance not very rugose. Coloration (alcoholic male
holotype): Quite similar to that of *bi-carinata*, save that the ventral blue (or
blue-black) patches are very abbreviated, and restricted to the pectoral area;

chin usually not as heavily maculated as in *bi-carinata;* occasional specimens are uniformly suffused with a deep blue-gray which completely obliterates any dorsal traces of pattern. Measurements of holotype: Snout to posterior border of ear, 11.5 mm; head width, 9.0 mm; snout to anus, 50 0 mm; hind leg (insertion to tip of 4th toe, exclusive of nail), 27 0 mm.

Distribution.— Guerrero, east of Tierra Colorada; Oaxaca, except the northeastern corner; eastern Chiapas (Tonolá).

Remarks —I have previously postulated *(loc. cit)* on the possibility of a subspecific relationship existing between *bi-carinata* and *anonymorpha* Through the kindness of Dr Hobart M. Smith I have been able to examine a large series of Utas from Morelos, Guerrero, Michoacán, and Oaxaca and Chiapas, which he has just recently returned with, after a protracted collecting trip in southern Mexico. A critical study of these specimens leaves no doubt that *bi-carinata* does in fact extensively intergrade with *anonymorpha* throughout the entire region from Acapulco east to Tierra Colorada, Guerrero. Specimens from the last named locality range from typical *anonymor-* *pha* to typical *bi-carinata,* with every conceivable degree of arrangement of the hybrid characters However, since the largest part of the specimens from Tierra Colorada are undeniably *anonymorpha,* I consider this point to be the westernmost range of this subspecies' distribution. The extension of the range of *anonymorpha* to include eastern Chiapas, is on the basis of two specimens collected by Dr Smith at Tonolá; a very large male and an immature female, both, however, somewhat atypical There is a strong possibility that specimens from more easterly Chiapas will prove to be distinct from *anonymor-* *pha,* and these two examples may indicate some such tendency.

Generally speaking, *anonymorpha* is quite easily separated from *bi-cari-* *nata* In males, the abbreviated blue abdominal patches are quite distinctive in *anonymorpha;* while the ventral coloration tends to take on the appearance of an evenly diffused wash in *bi-carinata* males In specimens of either sex, *anonymorpha* can be told at once by its much less rugose appearance, and the definitely weaker carination of the enlarged dorsals. More often too, *anonymorpha* will possess an evenly mottled chin, whereas *bi-carinata* has a tendency to possess a light median area; this has already been noted by Smith (1935, p 170). The holotype and paratypes on which the race is based agree very well with the series of 98 specimens taken by Smith

Uta bi-carinata nelsoni Schmidt   Figs. 1H, 2

Uta nelsoni Schmidt, Amer. Mus. Nov., No 22: 4.   1921.

Type locality —Cuicatlam (=Cuicatlán), Oaxaca

Type.—U. S. N M no. 46836.

Diagnosis.—Most closely allied to *bi-carinata* and *anonymorpha,* from which races it differs only as follows: Ventrals not mucronate; dorsolateral and lateral series of tubercular scales poorly developed; head narrower proportionately than in *bi-carinata,* and broader proportionately than in *anony-* *morpha;* enlarged dorsals smaller. Measurements of type. Snout to posterior

border of ear, 13.5 mm; head width, 10.5 mm; hind led (insertion to tip of 4th toe, exclusive of nail), 33.0 mm; snout to anus, 58.0 mm.

Distribution.—Restricted to the type locality.

Remarks.—*U. b. nelsoni* is designated as a subspecies of *bi-carinata* for the following reasons: The marked similarity in structure to the typical form and *anonymorpha;* the continuity and contiguity of its distribution with the *bi-carinata–anonymorpha* stock, the ranges of all three being juxtaposed; and the possibility that *nelsoni* represents an intermediate population in position between the *bi-carinata–anonymorpha* stock, and some form, as yet undescribed, from extreme northwestern Oaxaca and possibly southern Veracruz The range of mountains just north of the city of Oaxaca have undoubtedly served to keep *nelsoni* isolated from *anonymorpha;* specimens from the immediate vicinity of this city will do much to clarify the relationships between *nelsoni* and the more southerly Oaxacan race.

Of this subspecies I have examined only the type specimen. This lone individual is distinct enough from *anonymorpha* and *bi-carinata,* but only on the basis of the characteristics given above Other points of distinction given by Schmidt (*loc. cit.*) do not seem tenable.

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Uta bi-carinata tuberculata Schmidt   Figs. 1E, 2

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Uta tuberculata Schmidt, Amer. Mus Nov , No 22: 4.   1921.

Type locality.—Colima, State of Colima

Type.—A.M.N.H no. 13737.

Diagnosis —Most closely related to *bi-carinata,* from which it differs as follows: Enlarged dorsals larger, more regularly arranged; equal to, or larger than, the enlarged femoral and tibial scales; external to the enlarged dorsals but in contact with them, or separated by only one or two granules, there is a series of slightly enlarged scales, which are visibly keeled, but neither as large nor as prominent as the primary series of enlarged dorsals; dorsolateral and lateral tubercles and enlarged spinose scales very regularly arranged, but not as prominent as in *bi-carinata;* lowest series of lateral tubercles in contact with the ventrals, which are not sharply differentiated from the granular scales of the sides; ventrals rounded, occasionally submucronate; slightly keeled laterally; gular scales for the most part elongated and imbricate, save for a few immediately adjacent to the infralabials, which are granular and pavemented; frontal variable, usually divided transversely; postfemoral dermal pocket variable; coloration similar to *bi-carinata.* Measurements of type: Snout to posterior border of ear, 12 0 mm; head width, 9.0 mm; snout to anus, 45 0 mm; hind leg (insertion to tip of 4th toe, exclusive of nail), 27.0 mm.

Distribution.—Colima and Jalisco (Schmidt, *loc. cit.*); Presidio de Mazatlán, Sinaloa (Smith, 1935, p 171); southern Sonora (20 miles southeast of Alamos).

Remarks.—Other than some slight variation in color and pattern, the specimens I have seen agree rather well with the type, differing only in a few minor points.

Because of a dearth of Utas from southern Sonora to central Jalisco, the

distribution of *tuberculata* is imperfectly known. First known from Jalisco and Colima, the type series remained unique until Smith (*loc. cit.*) reported on a specimen taken by him just south of Presidio de Mazatlán, Sinaloa, which extended the range northward for about two hundred miles. In the course of an examination of Mexican Utas in the collection of the Museum of Comparative Zoology I came upon two specimens, M.C.Z. nos. 37856-7, collected near Guirocabo, 20 miles southeast of Alamos, Sonora. These two specimens are quite typical of the subspecies, and on the basis of their locality, the range of *tuberculata* is extended northward again for another two hundred and eighty miles. Dr. Smith tells me in a letter that this closely corresponds to the distributional pattern of *Sceloporus nelsoni*.

U b tuberculata is obviously a member of the neotropical *bi-carinata* stock; just what its relationships with the nearctic *lateralis* might be must await the discovery of further specimens from Sinaloa, southern Sonora, and northern Jalisco.

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Uta unica, sp nov.   Figs. 1D, 2, 3

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Uta bicarinata Cope, Rept. U. S. Nat Mus for 1898: 320–322, fig. 43.   1900·
   Holotype—U S N. M no 14248, female, "Chihuahua," collected by Edward Wilkinson.
   Diagnosis.—A medium-sized *Uta* belonging to the Mexican division of the *Uta ornata* complex, and characterized by only a single series of enlarged dorsal scales on each side of the enlarged vertebrals; general appearance not at all rugose; dorsal and ventral scales with a distinct tendency toward pavementation.
   Description.—Cephalic scales comparatively smooth; frontal entire, separated behind from the interparietal by a pair of frontoparietals; rostral much wider than high; supralabials 5-5, the fourth and fifth subocular in position; infralabials 7-7; auricular opening anteriorly denticulated by several enlarged, granular scales; a few scattered enlarged scales on the nape and shoulders, extending caudad from a point just posterior of a line joining the insertions of the fore limbs, along the vertebral line onto the base of the tail for a distance subequal to the length of the femur, is a series of enlarged scales, bordered on each side by a single series of much larger scales, which are, however, inferior in size to the enlarged scales of the femur, but larger than the enlarged tibial scales; enlarged dorsal scales only weakly carinated, and prominently pavemented; external to the enlarged scales and in contact with them, or more often separated by the width of the vertebral series, is another series of enlarged scales, spaced about two scale lengths apart; these latter equal to or slightly smaller than the enlarged scales bordering the vertebral series; the outer enlarged scales often surrounded by minutely enlarged tubercular scales; on the dorsolateral, lateral, and ventrolateral areas are evenly dispersed four longitudinal series of small clusters of slightly enlarged, somewhat convex scales, which are not at all rugose, the lowermost of these rows of clusters barely in contact with the ventrals, ventral scales imbricate and mucronate anteriorly, but medially, laterally, and posteriorly, they become rounded and quite pavemented, again becoming spinose and imbricate as they approach the anal region; ventrals abruptly diminishing in size to meet the lateral scales; gular scales pavemented and rounded anteriorly, but mucronate and imbricate posteriorly, and no-

ticeably increasing in this tendency, until in the region of the gular fold the scales are longer than wide and distinctly spinose; gular fold extending laterally and dorsally around the anterior edge of the insertions of the fore limbs, and met by a heavy postauricular fold; caudal scales large, prominently keeled, spinose, and at least basally, in irregular whorls of three verticils, of which the first is always prominently larger; postfemoral dermal pocket absent. Coloration of holotype (alcoholic). Dorsum of head and body greenish gray, the head finely reticulated with light brown, and the body with two light brown bands which are narrow on the vertebral line and widen as
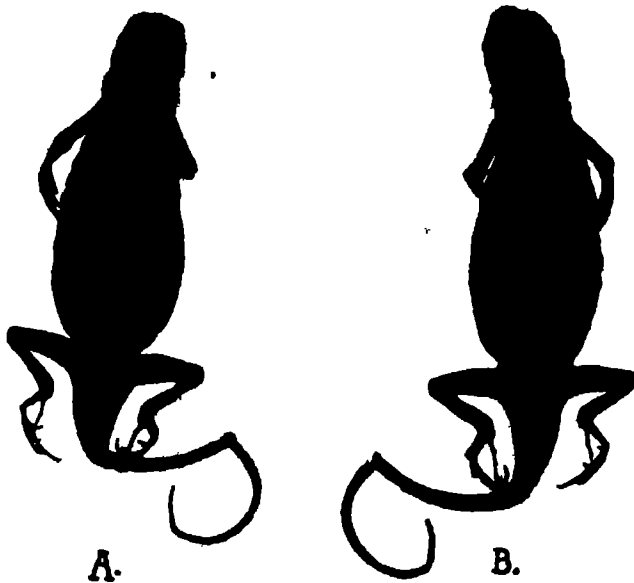
Fig. 3 —*Uta unica*, sp nov ; type, U S N M , no 14248, female, Chihuahua, Mexico. Edward Wilkinson, collector Actual length, snout to vent, 50 0 mm (A) Dorsal view; (B) ventral view

they progress laterally, dorsum of the body irregularly flecked and barred with dark brown; axillary, inguinal, lateral, prehumeral, postfemoral, and postanal regions washed with dark brown; an irregular, dark brown pectoral blotch; gular area and the remainder of the venter of body and tail a very pale greenish gray; limbs narrowly barred with light brown. Cope (*loc. cit.*) describes the specimen which was then fresh, as having "limbs and tail shaded with reddish brown," and says further that the "inferior regions tinted yellow lightly stippled with brown; males have the entire abdominal region a bluish gray." Measurements of holotype: Snout to posterior border of ear, 11.5 mm; head width, 9.0 mm; snout to vent, 50.0 mm; hind leg (insertion to tip of 4th toe, exclusive of nail), 26.5 mm; tail 52.0 mm.

Distribution.—At present known only from the southwestern (probably) corner of the state of Chihuahua.

Remarks.—This unique species is quite different from any other known *Uta*, and insofar as it can be determined, represents a dwarf offshoot of a probable pre-*tuberculata* stock Although immediately recognized as being distinct, formal recognition of it was deferred until such a time as might bring to light further specimens. Since a careful examination of several extensive collections of Mexican Utas has failed to reveal any additional specimens, I have, at the suggestion of Dr. H. M. Smith, described the species in the hope that future collectors working in southern Chihuahua may have the good fortune of taking more specimens. A study of the distributional patterns of the only other two Utas of the complex occurring in Chihuahua (*U. o. schmidti* and *U. caerulea*) leaves no doubt that the only suitable unoccupied ecological niche for this species would occur in the mountainous southwestern portion of the state, and it is from here that the type probably emanated. I can only attribute the lack of additional specimens to the fact that since Wilkinson collectors have largely neglected this part of Chihuahua

The distinctness of *unica* from other known Utas bespeaks quite a respectable age, as well as long separation from other members of the complex.

Uta caerulea Smith

Uta caerulea Smith, Univ. Kansas Sci Bull 12(7): 172-178, pl 26 (3)   1935.
  Type locality —Thirty miles north of Chihuahua City, Chihuahua
  Type.—David H. Dunkle-Hobart M. Smith Coll. no. 132.
  Diagnosis.—Two vertebral rows of enlarged, irregularly arranged, weakly carinated scales, extending from a point slightly craniad of a line joining the anterior points of insertion of the fore limbs, posteriorly onto the base of the tail for a distance equal to the length of the femur; vertebrals bordered on either side by two series of enlarged, imbricate, rather weakly carinated scales, the outer series slightly smaller; largest of the dorsal scales inferior in size to the largest of the tibials; dorsolateral tubercles but slightly enlarged, and dispersed in irregular little clusters; ventrals rounded, smooth, and imbricate; frontal transversely divided; a postfemoral dermal pocket present. Coloration of male (from original diagnosis, *loc. cit.*): Entire ventral surfaces of body and tail, except chest, base of tail, and an area between the hind legs, sky blue, dorsum with about seven transverse black bars on each side; bars usually blue-edged. Measurements of type (Smith, *loc cit.*): Snout to anterior border of ear, 10.0 mm; head width, 10.0 mm; snout to vent, 49.5 mm; hind leg, 30 0 mm.
  Distribution.—Within a radius of 30 miles of Chihuahua City, Chihuahua.

Remarks.—I include *caerulea* as a full species rather than as a subspecies with some reservations, as I have seen several specimens intermediate in character between *caerulea* and the newly described (Mittleman, 1940) *U. o. schmidti* from Texas and northern Chihuahua; these, however, bore only the data "Border," or "Mexico." I prefer to consider *caerulea* as a full species until the precise distribution of both forms in Chihuahua is completely mapped out

Uta caerulea is the only species within the *ornata* complex wholly indige-

nous to Mexico, that is a member of the subgroup within the complex which features two nearly equal series of enlarged dorsals on either side of the enlarged vertebrals; this condition regularly obtaining in the species indigenous to the United States. The characteristics of *caerulea* are such that they appear to be but newly differentiated from the *U. o ornata* and *U. o. schmidti* stock, a population which is in itself quite recent and still undergoing a proliferation as well as loss of numerous traits Smith (*loc. cit.*) has distinguished between *caerulea* and *ornata* (= *schmidti*), and enumerated several salient points of difference. In the main, the following distinctions will serve to separate the two forms: in *caerulea*, the enlarged dorsals extending onto the base of the tail for a distance equal to the length of the femur; never more than half this distance in *schmidti;* largest of the enlarged dorsals inferior in size to the enlarged tibials, in *caerulea;* in *schmidti*, these scales are equal to, or larger than, the enlarged tibials; *caerulea* with the blue of the gular region extending to include the sublabials; in *schmidti*, the sublabials are white or gray, but always distinct from the gular region in coloration. Smith also remarks that *caerulea* may be told from *lateralis* by the commencement of the enlarged dorsals on the nape of the neck in the latter; also, the inner series of enlarged dorsals much larger in size than the outer series.

PHYLOGENY OF THE COMPLEX

The *Uta ornata* complex is defined as that group of lizards within the genus *Uta* which is characterized by the possession of one or more series of enlarged dorsal scales bordering a similar though smaller series of vertebral scales; the group is so-named because *Uta ornata ornata* was the first described form within it. In the United States, Mexico, Baja California, the islands within the Gulf of California, and at least two of the islands composing the Revillagigedo Archipelago, there occur 15 species and subspecies of Utas, which, by reason of the common bond previously defined, are assigned to this complex.

Smith (1935, p. 177) has postulated that the genera *Uta* and *Sceloporus* have shared a common ancestor, *Uta* being possibly a trifle older than *Sceloporus*. Smith states further that the *ornata* group may be considered the most primitive in the genus *Uta*, and the *mearnsi* group the most highly developed. I find Smith's hypothesis substantiated, and ascribe to it too. *Uta* may be fairly well separated into four groups, these, in the order of their complexity and evolution from oldest to newest, being *ornata–graciosa–stansburiana–mearnsi*. The trend, apparently, in *Uta* is from a rugose, carinated, enlarged scaled form to a minutely scaled, smooth form.

Within the *ornata* complex, *wrighti* (= *levis* of Smith, *et auct.*) is probably the most primitive species. The primitive *Uta ornata* fore-

bear can be described as a *Uta* bearing weakly carinated, irregularly arranged, numerous series of enlarged dorsals; poorly developed series of enlarged dorsolateral and lateral tubercles; ventrals rounded; of existing Utas, *wrighti* most closely approaches this hypothetical form. Without delving into the ramifications of the proliferation of species within the United States, let it suffice to say that *wrighti* gave rise directly to the more rugose, larger scaled *linearis* of southern Arizona and northern Mexico. At about the time of the early Oligocene, *linearis* spread southward into what is now northern Sonora, which existed in a continuous range of land with the present-day Gulf of California, Baja California, and western Mexico as far west as the Revillagigedo Archipelago. This era saw the submersion of the west coast of Mexico from southern Jalisco to and including the Yucatan Peninsula.

The vanguard of the *linearis* emigration must have been characterized by an extreme genetic instability, for the foremost of these lizards soon formed the *lateralis*, or actually pre-*lateralis*, stock. The stock must have been of an active, aggressive, and successful nature; it spread in all possible directions, and soon became established in numerous ecological situations. That these lizards possessed an extremely active genetic constitution, and bore several strains, is attested to by the fact that the recession of the southern waters which formed the Gulf of California, the several islands within the gulf, the Revillagigedo Archipelago, and left southern Mexico dry, left several populations comparatively isolated, and these soon differentiated into distinct forms. The pre-*lateralis* population promptly continued its southward trek, while the remaining members evolved into the modern *lateralis*. The two small groups of lizards that were isolated on Socorro and Clarion Islands, respectively, of the Revillagigedo Archipelago, offer remarkable proof of the diversity of this pre-*lateralis* stock; for *auriculata* of the former island bears a closer resemblance to *bi-carinata* and its affiliates than it does to either *lateralis* or the neighboring *clarionensis* of Clarion Island. Conversely, *clarionensis* is more nearly related to *lateralis* than to *auriculata* or any other existing form.

The emersion of southern Mexico probably took place during the early Miocene, and the expansion of the pre-*lateralis* stock followed the recession of the waters, hampered only by the high Sierra Madre on the east, and the Pacific Ocean on the west. This southerly migration was accompanied by the adoption of variously isolated niches as well as changing genetics which similarly contributed to the differen-

tiation of several new forms. Ultimately, this resulted in the evolution of the line *lateralis–tuberculata–bicarinata–nelsoni–anonymorpha*, the latter two races probably developing simultaneously, with their distinction being due to the isolation afforded the *nelsoni* stock by the high mountains just north of Oaxaca (city). Additional specimens from more easterly localities in Chiapas may reveal that a still undescribed race exists there, for this region was separated from the Tehuantepecan area by a post-Miocene immersion, and did not become continuous with it again until the Pliocene, thus affording ample time for the differentiation of another race. This has been found to be the case with certain *Cnemidophori* (Burt, 1931, p. 73). *Caerulea* is quite probably but a newly differentiated species, sprung from the *ornata-schmidti* stock, from which it differs only in degree.

In the study of the evolution and phylogenesis of the Mexican *Uta ornata* lizards, certain characteristics lend themselves very well as salient indicator factors to the examination of such trends. These are: (1) the number and size of the enlarged dorsals; (2) the form of the ventral scales; and (3) the absence or presence of a postfemoral dermal pocket. The last-named feature occurs in all the forms indigenous to the United States, is present too in *U. caerulea*, also in *lateralis*, is variable in *tuberculata* and *bi-carinata* (although most often absent in this latter race); is always absent in *unica, anonymorpha*, and *nelsoni*, is possibly rudimentary in *auriculata*, and absent in *clarionensis*. The trend from *lateralis* to *anonymorpha* is from a smooth, rounded ventral scale, to a carinated, spinose one. Again *auriculata* and *clarionensis* reveal their closer affinity to certain mainland forms than with each other, for *auriculata* possesses ventrals almost indistinguishable from those of *bi-carinata*, while those of *clarionensis* bear a remarkable resemblance to the condition obtaining in *lateralis*. The southward progression of the races reveals too that there is a steady decrease in the size and number of the enlarged dorsals, from *lateralis* to *anonymorpha*; *clarionensis* again resembling *lateralis*, and *auriculata* the southerly races. In all of its traits, *unica*, as its name implies, is quite unique. On the whole, however, it seems to be a specialized offshoot of the pre-*tuberculata* stock.

From the preceding discussion it will be readily seen that the members of the Mexican division at least, of the *Uta ornata* complex, define themselves into a clearcut example of a formenkreis. Although the races indigenous to the United States have not been included here, it may be added that they just as readily incorporate into a similar pattern. Ample opportunity for differentiation through isolation and

extreme genetic activity has resulted in the several diverse forms. It is this hyperactive state of genetics that has produced the innumerable mutants which gave rise to the different species and subspecies; whether the mutants produced will survive and because of a possibly changed physiology seek an unoccupied ecological niche in which they may successfully multiply, or whether they will remain within the genetic scope of the parental stock, and add to the sum-total of what taxonomists are pleased to call the normal variation of the species, is the needle's eye through which the latent species-in-the-making must pass. In the case of the Utas under consideration, at least, the passage seems to have been successfully navigated several times. The evolution of the Mexican lizards of the *ornata* complex can perhaps be best described as a case of dynamic orthogenesis accompanied by constantly changing physiologies, and the success or failure of the ecological niche occupied. This, then, follows the pattern of multiplication of species through the isolation and mutation of older species, as postulated by Dunn (1934). However, there is no implication that of necessity any of the ancestral features need survive. Kinsey (1936, p. 54) has pointed out that within a complex or formenkreis "each species gives rise to one or to a limited number of new types without modifying the specific status or the existence of the older species." Hence, although an older parental species may be well established, and the newer derivative species equally well established, there is no implication necessary on the basis of the successful existence of the newer species, that any traits of the older form must necessarily be present, or have some survival value. The very existence of the newer population, regardless of any characteristics common to both stocks, is ample proof of its success. Neither is there any need for the assumption that within a single cohesive group, as a complex or formenkreis, there must be a continuity of traits. These traits may well appear in several members of the complex, but they may equally well be absent. A genetic change which is sweeping enough to cause the physiology of a lizard to become so altered that it cannot tolerate the parental habitat, may in itself cause, or may be accompanied by a change that will cause an equally sweeping change of form.

    In their distribution and evolution, the Mexican *Uta ornata* complex representatives bear a close resemblence to the patterns worked out for *Ctenosaura*, by Bailey (1928); there is an even more marked similarity in their distribution and specific proliferation with those worked out for the Mexican wasps of the genus *Cynips* by Kinsey (1936).

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

364TH MEETING OF THE BOARD OF MANAGERS

The 364th meeting of the Board of Managers was held in the Private Dining Room of the Cosmos Club on Friday, December 6, 1940. President CRITTENDEN called the meeting to order at 8:00 P.M , with 17 persons present.

President CRITTENDEN appointed G. W. VINAL, chairman, W. G. BROM-BACHER, and J. W. MCBURNEY to constitute the Committee of Tellers to canvass the ballots in the annual election of officers for 1941.

President CRITTENDEN appointed H. E McCOMB, chairman, F. S. BRACK-ETT, and L V. BERKNER to constitute the Committee of Auditors to examine the accounts of the Treasurer for the calendar year 1940.

C. L. GARNER, chairman of the Committee on Meetings, reported that all the meetings of the Academy through April, 1941, would be held in the present Assembly Hall of the Cosmos Club.

G. STEINER, chairman of the Committee on Membership, presented the names of 11 persons for membership in the Academy—9 resident and 2 nonresident.

The Corresponding Secretary presented for R. E. GIBSON, chairman of the Nominating Committee, the report of that committee on their nominations for officers for 1941:

For President	. . . .	AUSTIN H. CLARK
For Secretary	.	FREDERICK D. ROSSINI
For Treasurer .	. . .	HOWARD S RAPPLEYE
For Manager, to fill the unexpired term of two years, 1941 and 1942 . . .	•	FRANK H. H. ROBERTS, JR.
For Manager, for the regular term of three years, 1941, 1942, and 1943; with two to be elected	.	FERDINAND G. BRICKWEDDE HENRY B. COLLINS, JR. FRANK C. KRACEK PAUL A SMITH

In connection with the awards for scientific achievement, the following motion was made and carried by the Board: "The awards for scientific achievement announced at the annual meeting of the Academy in January shall be made for the preceding calendar year, and a candidate shall not have attained his 41st birthday during the year for which the award is made."

The Corresponding Secretary presented for the Committee of Tellers who counted the ballots on the three amendments to the bylaws submitted to the membership in October, 1940, which committee consisted of H. N. EATON, chairman, R S JESSUP, and B. J. MAIR, their report on the 150 ballots cast by the membership:

Amendment	For	Against
To restore the offices of the two nonresident vice presidents .	94	50
To modify and clarify the procedure for amending the bylaws . .	133	15
To establish the position of Archivist, to discontinue the office of Recording Secretary, and to change the name of the office of Corresponding Secretary to Secretary .	144	6

Since a two-thirds majority of the ballots cast is necessary for adoption, the first listed amendment was lost and the other two were carried.

The Corresponding Secretary reported the following statistics with regard to the membership: Deaths, 2; acceptances to membership, 11; resignations, 2.

In connection with the report of the Custodian of Publications, W. W. DIEHL, the following motion was made and carried: "The President is instructed to appoint a committee to consider (a) the number of copies of the Journal to be printed currently, (b) the limitations to be placed on the sale of back numbers of the Journal, and (c) the limitations, if any, to be placed upon the purchase of back numbers of the Journal to complete given volumes or entire sets of volumes." To constitute this committee, President CRITTENDEN appointed the Custodian of Publications, chairman, the Senior Editor, and the Treasurer

The meeting adjourned at 10:00 P.M.

FREDERICK D. ROSSINI, *Corresponding Secretary.*

Obituaries

WILLIAM BOWIE, U. S. Coast and Geodetic Survey, retired, died at Mount Alto Hospital in Washington, D. C., on the morning of August 28, 1940, after an illness of less than a month. He was born in Anne Arundel County, Md., on May 6, 1872, the son of Thomas John and Susanne (Anderson) Bowie. He received his early education in the public schools and at private academies and later received degrees at Trinity College, Lehigh University, University of Edinburgh, Scotland, and George Washington University.

He entered the service of the Coast and Geodetic Survey on July 1, 1895, and served as a junior officer and later as Chief of Party in the field and was engaged principally on triangulation and base-line measurements in many States of the Union as well as in the Philippines, Puerto Rico, and Alaska. He was appointed chief of the Division of Geodesy in 1909 and rendered distinguished service in this position until he retired on December 31, 1936.

During the World War he was commissioned a major in the Corps of Engineers, U. S Army, and served with the Mapping Division of the Office of the Chief of Engineers

His development of the theory of isostasy gained him international recognition. He was awarded the Elliott Cresson medal in 1937 by the Franklin Institute of Philadelphia for his contributions to the science of geodesy. He was also awarded the Charles Lagrange prize by the Royal Academy of Belgium, 1932; made an officer in the Order of Orange-Nassau by the Queen of the Netherlands in 1937; and received the decoration of the Cross of Grand Officer of the Order of St. Sava from Yugoslavia in 1939.

The first impression of the medal of the American Geophysical Union, known as the William Bowie Medal and established for award for distinguished attainment and outstanding contribution to the advancement of cooperative research in fundamental geophysics, was presented to Major Bowie at the meeting of the Union in April, 1939.

Major Bowie was interested in many scientific societies and organizations to which he contributed much of his time. He was president of the Washington Society of Engineers, 1914; president of the Philosophical Society of Washington, 1926; president of the Washington Academy of Sciences, 1930; chairman of the American Geophysical Union, 1919–22 and 1929–32; chairman of the Board of Surveys and Maps of the Federal Government, 1922–24; member of the Committee on Surveying and Mapping, American Engineering Council; president of the Society of American Military Engineers, 1938; chairman of the Division of Surveying and Mapping of the American Society of Civil Engineers since its organization in 1926; president of the District of Columbia chapter of the Society of Sigma Xi, 1935–36; honorary president of the Pan American Institute of Geography and History, 1929 to 1940; president of the International Geodetic Association, 1919–33; and president of the International Union of Geodesy and Geophysics, 1933–36. He was appointed executive secretary of the Society of American Military Engineers in December, 1939, and served in that capacity and as editor of the Society's magazine until his death.

EDWARD BROWNING MEIGS, formerly chief of the Division of Nutrition and Physiology of the U. S. Bureau of Dairy Industry, died on November 5, 1940, after a long illness. He was born in Philadelphia on September 10, 1879, and received an A.B degree from Princeton University in 1900. He

was graduated from the Medical School of the University of Pennsylvania in 1904 and remained there for two years as instructor in physiology.

In 1904 he took the course in physiology at the Marine Biological Laboratory and spent the following year at the University of Jena, doing research work in the physiology of muscular contraction. He was instructor in physiology at the Harvard Medical School from 1907 to 1910 and in 1910 was fellow in physiology at the Wistar Institute. He came to the Bureau of Dairy Industry in 1915 to take charge of the laboratory for the study of the nutrition of dairy cows. This laboratory was situated at Beltsville, Md., but for administrative purposes was a part of the Washington laboratories. However, Dr. Meigs was, from the beginning, entirely responsible for the research work and when, in 1936, all the work of the Bureau of the physiology of reproduction, milk secretion, and nutrition was combined he became chief of the newly created division.

The results of his work previous to entering the Government service were presented in 15 papers, many of which dealt with problems of muscular contraction. In his work at Beltsville he made a notable contribution to the knowledge of the mineral metabolism of the dairy cow and of the part of the roughage in supplying minerals and essential vitamins to milking cows. The results of this work were presented in 27 papers in various journals and Department of Agriculture publications.

The interference with the nutrition investigations by outbreaks of mastitis in the herd forced Dr. Meigs to give considerable attention to a study of the factors influencing the incidence of this disease, a problem that he attacked with characteristic thoroughness and freedom from the bias imposed by preconceived theories. Although this work was curtailed by the onset of impaired health, he was able to demonstrate that in the nutrition herd mastitis could be produced or cured almost at will by the control of physical conditions.

In his last few years his strength was so reduced by the inroads of disease that he was obliged to give up the administrative work of his position and to confine his efforts to the preparation for publication of results that had accumulated in his active years. It was characteristic of his devotion to his work that one of his last acts was to insure the safety of a manuscript on which he had been working intermittently as his waning strength permitted for three years.

As chief of a laboratory he was a leader rather than a director. His interest was always in the study of fundamental principles rather than in the more superficial feeding experiments with their practical application. Among his scientific achievements should be included the organization of the staff that he gathered about him and in which he inculcated his own high ideals of service He will be remembered by those who were fortunate enough to be among his friends and acquaintances for his scholarly attainments, his gentle and courteous manners, and his unfailing generosity in thought and action.

STATISTICS.—*Some thoughts on statistical inference.*[1]   W. Edwards Deming, Bureau of the Census.

Definition of a statistician.—In the development of the scientific method, it is usually assumed that all observations give the same result; e.g., that $F = ma$ exactly, always. The statistical method is the scientific method, modified—that is, brought up to date—to take account of the fact that all nature is subject to variations. The chief duty of a statistician is to study these variations and to design experiments so that they may provide the maximum knowledge for purposes of prediction; another is to compile data with the same object in view; and still a third function is to help bring about changes in the sources of the data. You can go back and substitute the word scientist for statistician, and have a good definition of a scientist.

Anyone who is interested in getting the most out of an experiment, and presenting the data in such form that they can be used for meaningful predictions, is something of a statistician. A qualified statistician, however, in addition to being accomplished in some branch of science, natural or social, must also be trained in probability and the mathematics of distribution theory. He must get in and work with the scientist and be one. Some statisticians, I suppose, are better than others, but the best statisticians are the best scientists. The statistician and the scientist have the same ultimate object in view, and they must work together under the same rules. The statistician has no special license. Often his special training in distribution theory is not so much help to a statistician as his training in other topics of science.

Every interpretation of data involves a prediction.—Scientific data have no meaning until they are interpreted, and there can be no interpretation except in a predictive sense. There is no such thing as scientific data merely as facts. The interpretation can not be separated from the prediction.

The idea of presenting experimental results as original data is familiar to all of us However, presentation as a prediction may not be so familiar; in fact some scientists and engineers may prefer to think of only two ways of presenting the results of experimental work, namely, as original data and as an interpretation. Closer examination reveals, however, that every meaningful interpretation involves a prediction (Shewhart,[2] Ch 3.)   •

Moreover,

.   there is no knowledge of external reality without the anticipation of future experience   There is no knowledge without interpretation   what the concept denotes has always some temporal spread (Lewis,[3] p 195)

Such simple concepts as blue and round, for example, embrace not an immediate quale, but some stable pattern of relations   Feeling the roundness of a marble as we roll it between thumb and fingers, or measuring a house, is again a temporally extended and ordered relation of apprehended qualia   The ascription of a substantive or an adjective is the hypothesis of some sequence in possible experience, or a multiplicity of such experiences (Lewis,[3] pp 129 and 132)

Every set of data, for generalizations and conclusions, is but a sample, and a sample of the past.—One may take data just for an inventory. There are times when it is highly important to have an inventory, as for purposes of taxation. Otherwise one takes data with the object of saying something about future data that will arise from the same cause systems, or of doing something about the source of the data so that future data will differ in a certain way from past data. You design and carry out experiments on the specific heat of steam, the fatigue of metals, the pitting of metal pipe, the disintegration of leather, not just to learn something about what the specific heat of steam was, or about those particular specimens, or the particular batches whence they were drawn, all of which were made in the past, but rather, to say what the specific heat of steam is going to be next month, or to help somebody make better or more uniform steel, leather, or pipe, in the future.

Usually you do not run experiments on all the materials and articles of a particular batch that were made in the past; you do not need to; you experiment on only part of them. You draw a sample. But even if you ran experiments on an entire batch, i.e., took a 100 percent sample of last month's production, you still would have only a sample of what would have been produced by the same machines or exactly similar machines, reoperated under the same essential conditions. You are obliged to experiment on materials or articles that were made in the past, with the object of drawing inferences about some that are to be made in the future.

[2] WALTER A SHEWHART   *Statistical method from the viewpoint of quality control.* (The Graduate School, Department of Agriculture, Washington, 1939)
[3] C I LEWIS   *Mind and the world-order*   (Scribners, New York, 1929.)

The collection of data, whether by a physicist in the laboratory, by a government census of population, agriculture, or unemployment, by a department store on its sales and complaints and quality of goods placed on the shelves, by a manufacturer who keeps records of the quality of his products, or by any other person, is for the ultimate purpose of taking some sort of action, or making recommendation for action. Even a classroom quiz is no exception; it is not given (we hope) just for the nuisance of it, but to enable the teacher to say, on the basis of past evidence, whether certain pupils will be able to go ahead in the future into more advanced work, or to hold a job. The teacher, if he is scientifically minded, will have still another object in view, namely, to improve his own teaching; by seeing how well or how poorly his pupils have picked up certain ideas that he has tried to instill into them in the past, he can judge his own work to see where he needs to adopt different methods of teaching in the future.

In taking readings with a galvanometer you can always conceivably take one more reading, but in actual practice you are satisfied with a finite number. From these readings taken in the past, you make statements about what someone else will find when he takes readings in the future. Whatever special studies are pursued by statisticians, the chief object of learning them is to acquire facility in making predictions from data, and in presenting data in such form that others can do the same.

What I am saying was voiced more succinctly by Fry of the Bell Telephone Laboratories, at the University of Pennsylvania Bicentennial Celebration:

> The statistical method is used for saying something about data that we are about to take, not what we have already taken [4]

A word on sampling and the census.—So far as scientific generalizations and predictions are concerned, the distinction between a sample and a complete count (a perfect census, tests run on all of last month's production, all the readings that you might have taken with your galvanometer but did not), is only one of degree. A complete count of last month's production is only a bigger sample than part of it. Both are samples of what might have resulted, and the kind of results that are to be expected in the future from the same underlying cause system. In population studies, the births, deaths, vocations, migrations, and educational attainments of a population are changed and directed by a myriad of chance causes, superimposed on certain underlying

[4] THORNTON C FRY   September 19, 1940   The quotation given may not be verbatim.

social and economic cause systems. A census, even if perfect, is subject to the variations of chance because it describes only one of the many possible populations that might have been found as the result of this combination of chance causes and main causes. Any generalizations (i.e., predictions) must recognize the fact that some other population might have resulted, and in fact must be expected to arise in the future, from the same underlying causes.[5]

How big a sample? The three components of knowledge.—Seeing, then, that we must make our predictions about the future from samples of the past, the question arises: How big must these samples be? How much data do we need? One distinguishing characteristic of a good scientist, I should say, is that he knows good data and knows when he has enough of it.

But how much is enough? 10, 20, 50, 100, or 1,000 readings? The answer is not a simple yes or no. It is tied up with the idea that a prediction, if it is to convey knowledge, must be based on evidence. The degree of belief in any prediction is closely linked with the prediction and the evidence. Shewhart (*op. cit.*, p. 86) exhibits the triangular relation shown below, linking the three components of knowledge:
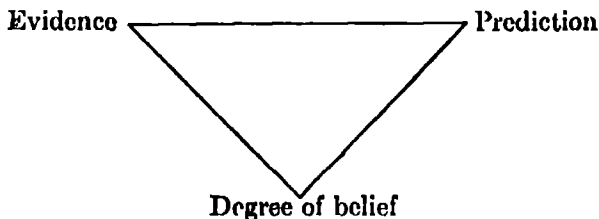
THE THREE COMPONENTS OF KNOWLEDGE

On the basis of certain evidence, you would make certain predictions, and in so doing, convey a certain degree of belief. A prediction is expressed in terms of data that one would expect to get if he were to perform certain experiments in the future. A prediction without any supporting evidence conveys no degree of belief. Thus, if I say it is going to rain day after tomorrow, I have made a prediction, but created no degree of belief, because you have no evidence, since I have no standing as a weather prophet. You would likely not carry your umbrella or cancel your trip on the basis of my prediction. The results of experimental work are usually summarized in terms of predictions and evidence. Shewhart gives a rule for the presentation of data, stat-

[5] This topic is pursued in more detail in a paper by W EDWARDS DEMING and FREDERICK F STEPHAN in the Journal of the American Statistical Association, March 1941.

ing that original data, if summarized, should be summarized in such a way that the evidence in the original data is preserved for all the predictions that are thought to be useful. Judgment is of course required in regard to just which predictions are to be assumed useful, but this is where scientific judgment must be exercised.

The question before us is how much data does one need? We are now ready to get back to it and look for an answer. I should say that one needs enough data—i.e., evidence—to provide some substantial degree of belief in whatever predictions he chooses to make or expects others to make. A physicist usually does not commence to record data for publication or calibration until his apparatus has been perfected to a state satisfactory to him; and he stops when further data, in his judgment, would create no greater degree of belief in any prediction that he may wish to make from that experiment.

Statistical control.—In the state of statistical control or the state of randomness, the data from an experiment, or the measurements on a product manufactured, display the characteristics of statistical stability. They behave as if they were samples being drawn at random from a stable universe. The ideal stable universe is a bowl of physically similar numbered chips. When they are thoroughly stirred and drawn blindfolded with replacement, the resulting sequence of numbers is the result of a random operation. (The necessity for extreme care in attempting to carry out any random operation, even in so simple an experiment as drawing numbers from a bowl, can hardly be overemphasized.) In experimental work, and in manufacturing, one can not form a judgment in regard to the attainment of statistical control until his experiment or process has been continued long enough to be subjected to Shewhart's Criterion I, which requires at least 100 readings.[6]

In the state of statistical control, the distribution theories of mathematical statistics apply, and it is possible to make a valid prediction concerning the next hundred or thousand observations; it is possible, for instance, to draw a pair of limits (control limits) such that whenever a future observation falls outside these limits, it will be worth while to look for an assignable cause of variation in the process.

The state of statistical control is the goal of all economic manufacture of materials. It is not usually the goal in experimental work in pure science; but this is only an illustration of the fact that some

[6] This criterion for randomness is discussed by SHEWHART in his *Economic control of quality* (Van Nostrand, 1931), pp. 304–318   For a description of a "normal" bowl, and the results of 4,000 drawings therefrom, see SHEWHART's *Economic control of manufactured product* (Van Nostrand, 1931), table 22 and Appendix II

requirements of industry are more exacting than the requirements of pure science. Usually an experimental physicist or chemist is satisfied to eliminate trends and erratic disturbances in his experiment to a point wherein he feels confident that he can draw a pair of limits that include any future observations that he might make by that method. He may continue making adjustments until he can set these limits narrower than has been possible in any previous similar experiment. If, with still further adjustments, his experiment were brought to a state of statistical control, still narrower limits could be set with even greater confidence. However, we shall find that the course adopted by the pure scientist is very often justifiable from the standpoint of accuracy, for the reason that any limits that he might draw on the basis of one experiment refer only to what may be expected from that particular method, but they do not by themselves give any indication of systematic errors nor of what may be expected from some other method of measurement.

Accuracy and precision.—Scientists have for long toyed with the hope of finding some logical method of inferring from a given set of data what the accuracy of those data may be. The idea is an exciting one, but it is a vain hope; the data of a single experiment, or even of a number of experiments, do not by themselves provide all the evidence that is needed for stating the true value of the thing being measured. For to say something about the true value, one must predict what will be the result of all other methods of measurement, not only those methods that have been tried out, but also all those that are yet to be devised. He must also be able to explain any discrepancies between different methods. More methods and more data (good data) add new evidence to our knowledge, but of knowledge there is no end. The concept of true value arises not from any highly consistent results arising from one experiment, but from consistent results from many different kinds of experiments. Think of the different ways of measuring e/m. When two or three of them had been discovered, and found to give consistent results, there was reason to begin thinking that something was known about e/m. But new data and new methods can always upset predictions, and such has been the history of physics. "Knowing begins and ends in experience; but it does not end in the experience in which it began."[7]

The objectivity of being able to make a valid prediction of the limits within which the future data of a single method of measurement will fall is in contrast with the subjectivity of assigning limits within

[7] C I Lewis *Experience and meaning*, Philos Rev 13: 134   1934

which the data of that and all other methods will fall. This contrast is expressed by the distinction between the words precision and accuracy. The limits set by a single experiment give a measure of the precision of that experiment, or of that method of measurement, but they give no objective criterion of the accuracy of the result, because they refer to the one experiment only, and not to all the other methods that are or have been devised.

In order to convey knowledge, the Δx in $x \pm \Delta x$ must have an operationally verifiable meaning in the form of a prediction. This will be one sort of a prediction in a statement regarding precision, but a very different one in a statement regarding accuracy.

To see how these remarks apply in practice, let us think of a certificate issued by the National Bureau of Standards on a precision standard.

UNITED STATES DEPARTMENT OF COMMERCE
WASHINGTON
NATIONAL BUREAU OF STANDARDS

— --

Certificate
for
Standard Resistor

Manufactured by _ _ _ _ _   _ _ _ _ _, Serial No _____

Submitted by

The _ _ _ _ _____   _____ _____ Company

of ___ _ ___ _ _____ _

The above-described resistor was found in September 1940, at a temperature of 25°C, to have a resistance of

9.9999 International Ohms

The value given is correct within 0 005 percent This statement of accuracy takes into consideration the uncertainty in the realization of the International Ohm from its definition and allows for normal changes of resistance with time

LYMAN J BRIGGS, *Director*

Let us try to see the element of prediction in this certificate. Perhaps we shall agree that a certificate is a prediction. When a piece of apparatus is of such poor quality that you dare not risk a prediction on it, you do not issue a certificate, but may instead issue a report. In issuing a certificate you risk making a prediction regarding the future behavior of a piece of apparatus that was sent in for test; in a report you merely record a bit of history—how it behaved, in terms of your own standards—while it was here. You leave the risk of prediction to the owner of the apparatus.

In the testing of precision standard resistors at the National Bureau

of Standards, the measurements can ordinarily be duplicated within a range of 1 part in 100,000 to 1 part in 10,000,000, depending partially on the magnitude of the resistor, but more particularly on its quality. In the example given above, the measurements can be duplicated from day to day with variations of not more than one unit in the fifth decimal place, and the resistance is therefore determined in terms of the N.B.S. Ohm to within this magnitude. These are statements of precision and are objective. As for accuracy—comparison with the International Ohm, and behavior after being shipped back to its owner—you are obliged to depend on intuition. You allow a wide factor of safety; your certificate risks a prediction that is 50 times as wide as the latitude of reproducibility of your measurements. You did not make a direct comparison with the International Ohm, and you did not run a test on the change of resistance of this particular resistor with time, and certainly not after it was sent back to its owner. But you have had many years' experience with similar resistors, and you are led by intuition to make statements (predictions) regarding the accuracy of this particular one. You feel safe in predicting its behavior. For resistors of better quality, you would name narrower limits, and for one of particularly good quality, you might even make a prediction regarding the variation of its resistance with temperature.

In a certificate you are not talking about your own apparatus: you are talking about the apparatus that was sent in for test.

Intuition may at times be very helpful, but intuition, like the conscience, must be trained. The distribution theory of statistics should be a part of this training. The rest of us may well be satisfied to pin our faith on the intuition of an expert. And perhaps our own intuition helps us to distinguish between experts and others whose intuition is not so reliable.

Pure distribution theory, by itself, is nigh helpless until the state of statistical control is attained and proved. Since statistical control seldom exists in experimental work, the interpretation of scientific data remains, for the most part, a matter of cooperation between the statistician and the scientist, each assisting the other in the process of adjusting the apparatus, and finally in making predictions from the results. The peculiar training of the statistician enables him to help the physicist or engineer to weed out assignable causes of variation and to attain uniformity; in fact, as I said, one of the chief duties of a statistician is to help bring about desirable changes in the source of the data that he takes. His services are especially useful in industry,

where the economic advantages of statistical control are coming to be more and more recognized. Huge financial savings are being effected, not only in industry, but also in a number of government departments by the application of statistical methods.

My main theme is that the interpretation of scientific data involves prediction. Facts, so far as science is concerned, have meaning only in the predictions that can be made from them. A prediction must be made in terms of some operation that will prove the prediction either true or false. The methods of the statistician take into account the variabilities in nature, and his special training enables him to make the most efficient use of data for valid predictions when it is possible to make predictions. He also knows when predictions can not be made. The statistical method is an aid to the scientist in understanding the nature of the knowledge that he is continually seeking.

In conclusion, it is a pleasure to express my indebtedness to conversations with Dr. Frank Wenner of the National Bureau of Standards, particularly in regard to the interpretation of certificates.

BOTANY.—*Names in* Amaranthus, Artocarpus, *and* Inocarpus.[1] F. R. FOSBERG, U. S. Bureau of Plant Industry. (Communicated by W. T. SWINGLE.)

To make available the correct names for certain species and to save other workers the trouble of searching the literature for a solution to the *Amaranthus tricolor* problem, it seems worth while to publish the notes given below.

Amaranthus tricolor L. [Amaranthaceae]

In *Species plantarum*, ed 1, p 989, 1753, Linnaeus described *Amaranthus tricolor*, *A. melancholicus*, and *A. tristis*, distinguished by trifling differences in leaf color and outline. In edition 10 of the *Systema*, p. 1268. 1759, he added *A. gangeticus*, also very closely allied to the above three Various other species were added to the complex later, but as they have no bearing on the nomenclatorial problem, they will not be discussed here. The object of this note is to establish which of the above names is correct if all four names are considered synonymous, the opinion held by most modern botanists.

Botanists generally, with the exception of Lamarck and Moquin, up to the time of Hooker's *Flora of British India* (1885), followed Linnaeus without question in recognizing at least four species. Lamarck, in the first volume of the *Encyclopédie méthodique* (p 115. 1783) made *A melancholicus* L a variety of *A. tricolor* L , but recognized *A. gangeticus*, *A. mangostanus*, and *A tristis* as distinct species. Poiret, in the *Supplement* (vol 1, pp 311–312.

1810) and in the text to the *Tableaux* (p. 355, text for pl. 767. 1823) restored *A. melancholicus* to specific rank.

Moquin, in DeCandolle's *Prodromus* 13 (2): 262. 1849, evidently misinterpreting Poiret's synonymy, made *A tricolor* a variety of *A. melancholicus*, citing the *Tableaux* as authority   •

Boissier, in the *Flora Orientalis* 4: 990. 1879, mentioned only *A. gangeticus*, giving neither synonyms nor related species.

J. D. Hooker, in the *Flora of British India* 4: 719–720 1885, reduced *A tricolor*, *A melancholicus*, and *A. tristis* (the latter with some doubt) to the later *A. gangeticus*. The reason for this abrogation of the rule of priority is not clear to me. Perhaps it was simply an oversight due to the unfortunate custom, then in vogue, of omitting the dates from all reference citations At any rate, *A gangeticus* can not be the correct name for the aggregate British botanists, during the next quarter century, except Hiern in the *Catalogue of Welwitch's African plants* 2: 887. 1900, and Baker and Clarke in the *Flora of Tropical Africa* 6 (1)· 32 1909, followed Hooker's disposition of the matter Some other botanists (cf. Kung Hsien-wu in Liou Tchen-ngo, *Fl Ill. du nord de la Chine* 4: 15 1935) even much more recently, are still following him, in obvious disregard of the rules of nomenclature

Fiori and Paoletti, in *Flora analitica d'Italia* 1: 321 1898, were the first modern botanists to reduce *A. gangeticus*, *A. mangostanus*, and *A. melancholicus* to *A tricolor* *A gangeticus* was maintained in a subordinate category. No mention was made of *A. tristis*

In this century Hiern (see above), Baker and Clarke (see above), Thellung (in Ascherson and Graebner, *Syn Fl Mittel-Eur* 5: 272–280 1914), Merrill (*Enum. Phil. Fl Pl* 2: 128 1923 and other papers), and Bailey (*Man. Cult Pl* 252 1924) have followed this course, which seems to be the correct one

Article 56 of the International Rules (Cambridge) reads, in part: "When two or more groups of the same rank are united . . . if the names or epithets are of the same date . . the author who first adopts one of them, definitely treating another as a synonym or referring it to a subordinate group, must be followed " Strict application of this rule makes it quite clear that the reduction by Lamarck (*Encycl.* 1: 115 1783) of *A. melancholicus* to a variety of *A. tricolor* determines that the latter is the correct name for the aggregate (unless someone should show that two or more of the species had been combined previous to Lamarck's publication).

The essential synonymy to establish this point is given below. The extensive post-Linnaean synonymy is largely unnecessary here and may be found in the intricate treatment of *A tricolor* L. by Thellung in Ascherson and Graebner, *Syn Fl. Mittel-Eur.* 5: 272–280. 1914

Amaranthus tricolor L Sp Pl. 989. 1753

  Amaranthus melancholicus L. Sp. Pl. 989. 1753
  Amaranthus tristis L Sp. Pl. 989 1753.
  Amaranthus gangeticus L. Syst. X: 1268. 1759.
  Amaranthus mangostanus L. Cent I: 32. 1755.

Amaranthus tricolor L. var. *melancholicus* Lam. Encycl. **1**: 115. 1783.
Amaranthus melancholicus L. var. *tricolor* Lam. ex. Moq. in DC. Prodr
  13 (2). 262. 1849.

Artocarpus altilis (Parkinson) Fosberg [Moraceae]

In a longer paper, not as yet published, I have discussed the validity of the names published in Parkinson's *Journal of a voyage to the South Seas in H M.S Endeavour*, etc., published in 1773 As it may be some time before this paper is published, it seems desirable to make the necessary combinations for this and the following well-known species, so that they may be used

The well-described genus *Sitodium* Parkinson antedates by three years *Artocarpus* Forst. I have elsewhere (Amer. Jour. Bot. **26**: 231 1939) proposed *Artocarpus* for conservation, as it contains well-known economic plants (breadfruit, jakfruit), but, owing to the European war, there seems little chance of holding a congress in the near future to vote on such propositions In the meantime it seems desirable to go on using the name *Artocarpus*, rather than making a temporary shift to the unfamiliar *Sitodium* Since the principle of conserved specific names was decisively rejected by the congress in 1935, it is necessary to transfer Parkinson's specific epithet to *Artocarpus*.

E J H Corner, in a well-thought-out article in Gard Bull S. S. **10**: 280–282. 1939, discussed the reasons why *Artocarpus incisus* (Thunb) L. f should be used for the common breadfruit rather than *A. communis* Forst , both specific epithets published the same year (1776), with no indication available as to which was earlier The problem would have been solved without the discussion had Corner been aware of the availability of Parkinson's epithet, published three years earlier The combination and synonymy follow:

Artocarpus altilis (Parkinson) Fosberg, n comb.

Sitodium altile Parkinson, Journ Voy. *Endeavour* 45 1773.
Artocarpus communis Forst Char. Gen 101. 1776.
Radermachia incisa Thunb Handl Vet -Akad Stockh. **37**: 254 1776
Artocarpus incisus (Thunb) L. f. Suppl 411 1781

Corner's spelling of Thunberg's generic name *Rademachia* instead of *Radermachia* is an error that, according to the *Index Kewensis*, originated with Steudel

Inocarpus fagiferus (Parkinson) Fosberg [Leguminosae]

Aniotum Parkinson, as in the case of *Sitodium* mentioned above, antedates a well-known generic name, *Inocarpus*, the Tahitian chestnut, *mape* (Tahiti), *kopit* or *kerepit* (Malay, cf Corner, Gard Bull. S. S. **10**: 269. 1939) As with *Artocarpus*, I have proposed *Inocarpus* for conservation, and for the same reasons as given above, I am here making the combination for Parkinson's specific name under *Inocarpus*.

Inocarpus fagiferus (Parkinson) Fosberg, n comb.

Aniotum fagiferum Parkinson, Journ Voy *Endeavour* 39 1773.
Inocarpus edulis Forst Char Gen 66 1776.

Corner (Gard. Bull S. S. 10: 269-270. 1939) in his discussion of whether this species is native in Malaya cast some doubt on the statement of Brown (Bishop Mus. Bull. 130: 118 1935) that in the Marquesas this species reaches a height of 10 meters. He describes it as "a smallish and slow-growing tree." I know nothing about the rate of growth and have not actually measured any trees No one, however, who has seen the trees of this species in some of the deep valleys of Tahiti (Aparé Maué, Papenoo, etc.) could possibly describe the tree as smallish It has huge buttressed trunks, many feet in diameter, that compare favorably with the giant ceiba trees shown in tropical pictures, and tho trees are certainly well in excess of 10 meters tall.

BOTANY.—*New Acanthaceae from Guatemala.*[1] E. C. LEONARD, U. S. National Museum. (Communicated by WILLIAM R. MAXON.)

During the 1938-39 Sewell Avery Expedition of the Field Museum of Natural History to Guatemala, Paul C. Standley collected a considerable number of Acanthaceae. In the present paper, based on a study of these specimens, six new species are described, one is transferred from *Eranthemum* to *Pseuderanthemum*, and one is renamed.

Ruellia brittoniana Leonard, nom nov.   Fig. 1

Cryphiacanthus angustifolius Nees in DC. Prodr. 11: 199 1847. Not *R. angustifolia* Sw , 1788
Ruellia spectabilis Britton, Ann New York Acad 7: 192 1893; not Nichols, 1886.

Fig 1 —*Ruellia brittoniana* Leonard a, Portion of plant, half natural size; b, capsule, natural size

Cultivated near Quiriguá, Department Izabal, Guatemala, altitude 70 to 150 meters, April 26-27, 1939, *Standley 72225.*

[1] Received November 8, 1940.

Ruellia donnell-smithii Leonard, sp. nov   Fig. 2

Herbae, caulibus quadrangularibus superne cano-pilosulis, infra glabratis; lamina foliorum ovata vel oblongo-ovata, obtusa, basi angustata in petiolum decurrens, integra vel leviter undulata, cano-pilosula, subtus glandulis rotundatis vestita; flores subsessiles axillares solitarii subterminales; calycis segmenta glanduloso-pilosula, lineari-lanceolata; corolla purpurella, parce

Fig 2 —*Ruellia donnell-smithii* Leonard. *a*, Portion of plant; *b*, calyx, *c*, capsule. (*a*, half natural size; *b*, *c*, natural size)

puberula; capsula puberula glandulis rotundatis vestita; semina nigra, plana, suborbicularia, madefacta dense mucoso-pubescentia

Erect or decumbent herbs up to 30 cm high or more, stems simple or branched, quadrangular, the tips densely gray-pilosulous, the lower portions often glabrate; leaf blades ovate to oblong-ovate, 2 to 5 cm long, 1 to 2.2 cm wide, obtuse, narrowed at base and decurrent on the petiole, entire or shallowly undulate, grayish-pilosulous, or the older leaves subglabrous, the under surface with scattered roundish glands; petioles 2 to 4 mm long; flowers axillary, solitary, subsessile, borne at or near the tip of the stems; calyx glandular-pilosulous with spreading hairs without, strigose within, the tube 2 mm long, the segments linear-lanceolate, 10 to 12 mm long, 1.25 mm wide at base, gradually narrowed from above the base to a slender blunt tip; corolla 3 to 4 cm long, light purple, sparingly puberulent, the lower half of the tube slender, about 1.5 mm in diameter, the upper portion obconic, about 1 cm broad at the mouth, the limb spreading, 2 5 to 3 cm broad, the lobes suborbicular, 10 to 12 mm wide, rounded; filaments glabrous, one of each pair 2 mm long, the other 7 mm long; ovary puberulent, style 2 cm long, puberulent; capsule 10 to 12 mm long, 4 mm broad toward tip, narrowed to a solid stipitate base 3 mm long and 2 mm broad, puberulent, with small round glands; seeds flat, black, suborbicular, 4 mm in diameter, mucilaginous-pubescent when moistened

Type in the U. S. National Herbarium, no 944013, collected at San Luís, Department Escuintla, Guatemala, March, 1890, by John Donnell Smith (no. 2015).

Additional specimens examined:

MEXICO: Mount Ovando, Chiapas, March 30, 1935, *Matuda* 123.

GUATEMALA: Below Las Lajas, Department Escuintla, altitude 900 to 1,200 meters, in a dry thicket, February 9, 1939, *Standley* 64807.

Close to *R. geminiflora* H.B.K but readily distinguished by its densely glandular-pilosulous calyx

Ruellia standleyi Leonard, sp nov   •   Fig. 3

Herbae viscidae, caulibus subquadrangularibus, glanduloso-pilosis; lamina foliorum ovata vel elliptica, pilosula, apice breviter acuminata, basi rotundata

Fig 3—*Ruellia standleyi* Leonard a, Tip of panicle, b, leaf, c, calyx; d, ovary and style; e, portion of panicle from fruiting plant (a, natural size; b, half natural size; c, d, e, natural size)

vel truncata; petioli glanduloso-pilosi, panicula terminalis, glanduloso-pilosa; calycis segmenta lineari-subulata, glanduloso-pilosa; corolla anguste campanulata, lobis parvis; capsula oblonga, glabra vel apice parce pubescens; semina plana, brunnea, madefacta mucoso-pilosa

A viscid herb up to 1 3 meters high; stems subquadrangular, glandular-pilose or the lower portions glabrate; leaf blades ovate to elliptic, up to 15 cm long and 10 cm wide, short-acuminate, narrowed, rounded or truncate at the base, pilosulous, the pubescence denser beneath than above, the costa

and lateral veins (5 to 8 pairs) rather prominent; petioles up to 9 cm long, glandular-pilose; inflorescence a terminal, much branched, glandular-pilose panicle, the flowers rather numerous, subsessile, axillary or borne in the forks of the branches of the panicle; bracts lanceolate to subulate, small, or the lowermost larger and leaflike, calyx 15 mm long at maturity, the segments linear-subulate, rounded at tip, glandular-pilose, the hairs spreading, rather scattered, up to 1 5 mm long; corolla up to 18 mm long, finely pubescent, narrowly campanulate, the lobes about 3 mm long; stamens glabrous, the filaments of the longer pair about 4 mm long, those of the shorter pair about 2 mm long, the anthers about 2.5 mm long; style about as long as the corolla; capsules oblong, 15 mm long, 3.5 mm broad, glabrous or bearing a few minute hairs toward the tip, 8- to 10-seeded; seeds brown, flat, 2.5 mm long, a little more than 2 mm broad, finely gelatinous-pilose when moistened.

Type in the herbarium of the Field Museum of Natural History, no 992848, collected on Finca Pirencos, below Santa María de Jesús, Department Quezaltenango, Guatemala, altitude 1,350 to 1,380 meters, in a damp forest, March 11, 1939, by Paul C. Standley (no. 68390).

Additional specimens examined:

DEPT QUEZALTENANGO: Damp forest near El Muro, below Santa María de Jesús, altitude about 1,200 meters, *Standley* 67150

DEPT. SUCHITEPÉQUEZ: Wet thicket near Pueblo Nuevo, altitude about 750 meters, *Standley* 66970.

DEPT. SAN MARCOS. Wet thicket along Río Ixpal, below Rodeo, altitude about 750 meters, *Standley* 68720

This is closely related to *Ruellia paniculata* L , but it can be distinguished easily by its large, nearly naked terminal inflorescence and larger capsules, in *Ruellia paniculata* the inflorescence being axillary and leafy and the capsules narrowly cylindric and not over 9 mm long. It resembles more closely *R ochroleuca* Mart , but in that species the inflorescence is not glandular. From herbarium material it is impossible to determine the color of the corolla.

Pseuderanthemum praecox (Benth.) Leonard, comb. nov.

Eranthemum praecox Benth. Pl Hartw 291 1848
Siphoneranthemum praecox Kuntze, Rev. Gen Pl 497. 1891

Dry oak and pine forest near San Martín Jilotepeque, Department Chimaltenango, Guatemala, altitude about 1,800 meters, February 3, 1939, *Standley* 64391 Dry rocky hills north of Santa Rosa, Department Baja Verapaz, Guatemala, March 30, 1939, *Standley* 69829.

Dicliptera debilis Leonard, sp. nov.   Fig. 4

Herba debilis, caulibus parce pilosis; lamina foliorum ovata vel lanceolata, acuminata, basi angustata, in petiolum decurrens; cymae axillares, subsessiles, bracteis triangulari-ovatis, cuspidatis, coriaceis, carinatis, ciliatis, carina strigosa; bracteae floriferae oblanceolatae, obtusae vel rotundatae, apiculatae; bracteolae lanceolatae, puberulae; calycis segmenta subulata; corolla subrufa, minute pubescens, capsulae parce glanduloso-puberulae.

Weak herb; stems up to 3.3 meters long, sparingly pilose, the hairs retrorsely curved; leaf blades ovate to lanceolate, acuminate (the tip blunt), narrowed at base and decurrent on the petiole, sparingly pilose except the

costa, this densely hirtellous; petioles slender, up to 1.5 cm long, hirtellous, the hairs curved; flowers borne in subsessile, axillary, 3-parted cymes; bracts subtending the cyme triangular-ovate, 3 to 3.5 mm long, 1.5 to 2 mm wide, cuspidate, coriaceous, carinate, ciliate, the keel strigose; bracts subtending the flowers oblanceolate, obtuse or rounded, apiculate, pilosulous without, puberulent within (some of the hairs glandular), the larger of the middle pair about 1 5 cm long and 7 mm wide, the larger of the lateral pairs 12 mm long and 6 mm wide, the smaller bracts of each pair 8 mm long and 3 5 mm wide;

Fig. 4 —*Dicliptera debilis* Leonard· a, Portion of plant; b, bracts subtending the cyme; c, bracts subtending the flowers (inner surfaces); d, calyx segment (a, natural size, b, twice natural size; c, natural size; d, twice natural size.)

bractlets lanceolate, the larger pair 6 mm long, slightly over 1 mm wide, the smaller pair 5 mm long and slightly less than 1 mm wide, all puberulent; calyx 8 mm long, puberulent, the segments subulate, 6 mm long, 1 mm wide at the base; corolla 2 5 to 3 cm long, pale red, minutely pubescent, the tube slender; capsules (immature) 1 cm long, sparingly glandular-puberulent.

Type in the herbarium of the Field Museum of Natural History, no 992431, collected north of Santa Rosa, Department Baja Verapaz, Guatemala, in pine-oak forest on a dry rocky hill, March 30, 1939, by Paul C. Standley (no 69823).

Apparently unrelated to any other Central American member of the genus. The lower leaves, early deciduous and absent in the type specimen, are probably larger than the uppermost, from which the measurements are taken.

Dicliptera inutilis Leonard, sp. nov.   Fig. 5

Suffrutex, caulibus parce et minute pubescentibus, deorsum glabris; lamina foliorum ovata, acuminata, basi angustata, hirtella; cymae axillares et terminales breviter pedunculatae, 3-partitae; bracteae floriferae oblongo-ovatae, subobtusae, basi truncatae, virides, venosae, parce pubescentes;
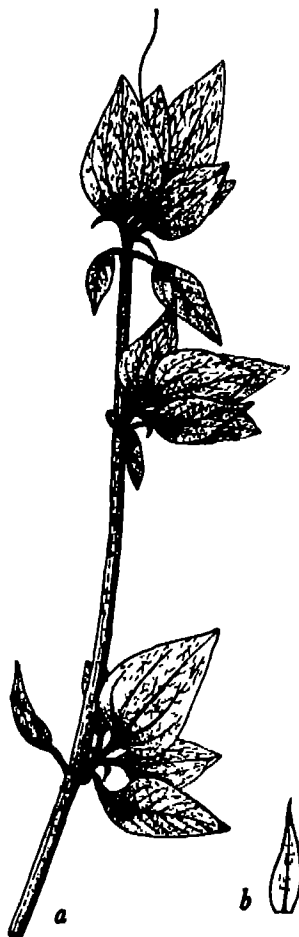

Fig. 5.—*Dicliptera inutilis* Leonard. *a*, Portion of plant, natural size; *b*, bractlet, twice natural size

bracteolae lanceolatae; calycis segmenta lanceolata, minute pubescentia; corolla purpurea, parce pubescens

Shrubby herb up to 1 3 meters high; stems much branched, sparingly and minutely pubescent, or the lower parts glabrate; leaf blades (uppermost) ovate, up to 4 cm long and 3 cm wide, acuminate (the tip blunt), narrowed at base, hirtellous, the hairs confined chiefly to the costa and veins; petioles up to 1 cm long, hirtellous; flowers borne in axillary and terminal short-peduncled 3-parted cymes, the peduncle 1 to 3 cm long, subtomentose; bracts subtending the middle cluster of flowers oblong-ovate, up to 2 cm

long and 1.2 cm wide, subobtuse, truncate at base, green, veiny, sparingly puberulent, the bracts of the lateral clusters similar but smaller; bractlets lanceolate, up to 6 mm long and 1 5 mm wide, minutely pubescent beneath, glabrous above; calyx segments lanceolate, about 5 mm long and slightly more than 1 mm wide, minutely pubescent; corolla 2 to 2.5 mm long, rose-purple, sparingly pubescent; capsule not seen.

Type in the herbarium of the Field Museum of Natural History, no. 993732, collected at Los Llanitos, near San José Acatempa, Department Jutiapa, Guatemala, altitude about 1,200 meters, in a moist thicket, December 21, 1938, by Paul C Standley (no. 60579).

Distinct from other Central American species of *Dicliptera* in its subsessile 3-parted cymes and its rather large, oblong-ovate, green, veiny bracts. The lower leaves, early deciduous and therefore lacking in the type material, probably exceed the dimensions here given for the uppermost leaves

Dicliptera membranacea Leonard, sp nov.   Fig. 6

Herba, caulibus ramosis, glabris vel ad nodos parce et minute pubescentibus; lamina foliorum ovata vel oblongo-ovata, subobtusa, acuta vel breviter acuminata, basi angustata, in petiolum decurrens, glabra vel subtus parce pubescens; petioli graciles; cymae sessiles vel subsessiles, flabelliformes, axillares vel terminales, bracteis ovatis, viridibus, venosis, subtus minute pubescentibus, basi cuneatis, marginibus angustis albis; bracteae floriferae inaequales oblanceolatae, parce pilosulae, ciliatae, apice rotundatae apiculataeque vel acutae, virides, margine basi alba; bracteolae lineares, albidae, acuminatae, ciliatae; calycis segmenta subulata, puberula, subhyalina; corolla pubescens, purpurella, tubo gracili; ovarium pubescens

Branching herbs up to 1 3 meters high; stems glabrous or sparingly and minutely pubescent at nodes; leaf blades ovate to oblong-ovate, up to 10 cm long and 6 cm wide, subobtuse to acute or abruptly acuminate (the tip blunt), narrowed at base and decurrent on the petiole, thin, drying bright green, glabrous or with a few minute hairs beneath; petioles slender, up to 4 cm long, glabrous or sparingly pubescent; flowers borne in sessile or subsessile axillary and terminal fanlike cymes, usually of 4 flowers each; bracts subtending the cymes ovate, up to 12 mm long and 6 mm wide, green, veiny, leaflike, sparingly and minutely pubescent beneath, glabrous above, the cuneate basal portion with a narrow white margin, bracts subtending the flowers unequal, oblanceolate, green with a narrow white border at the base, sparingly pilosulous, ciliate, the larger pair subtending the middle flower cluster 12 mm long and 6 mm wide, rounded at apex and minutely apiculate, the smaller bracts 10 mm long and 3 mm wide, rounded and apiculate, the bracts subtending the lateral flower clusters successively smaller and more acute; bractlets subtending the flowers linear, the larger pair 11 mm long and 1 5 mm wide, the smaller pair 9 mm long and 1 mm wide, all acuminate, whitish, 1-nerved, ciliate, the costa hirtellous; calyx segments subulate, 6 mm long, 0 5 mm wide, subhyaline, ciliate, 3-nerved, puberulent; corolla 13 mm long, pubescent, pale purple, the tube slender; ovary pubescent; capsule not seen.

Type in the U. S National Herbarium, no 1780239, collected between Río Jute and Río Pantaleón, on the road between Escuintla and Santa Lucía Cotz, Department Escuintla, Guatemala, in a thicket, altitude 540 to 720 meters, January 24, 1939, by Paul C. Standley (no. 63524); duplicate in the

herbarium of the Field Museum of Natural History. No. 63515 of Mr. Standley's collection, from the same locality, is this species also.

Dicliptera membranacea apparently has no close relatives in Central America. The specific name alludes to its thin, green leaf blades.

Fig 6 —*Dicliptera membranacea* Leonard *a*, Portion of plant, natural size, *b*, one of the bracts subtending the cyme; *c*, bracts subtending the middle flower cluster of a cyme; *d*, bractlets; *e*, calyx segment (*b, c, d, e*, twice natural size)

Streblacanthus parviflorus Leonard, sp. nov.   Fig. 7

Suffrutex, caulibus terctibus, bifariam pubescentibus; lamina foliorum elliptica vel late lanceolata, acuminata, basi rotundata, membranacea, integra, glabra, costa et venis minute pubescentibus exceptis; petioli graciles; spicae terminales et axillares; bracteae bracteolaeque filiformi-subulatae, minute pubescentes; calycis segmenta filiformi-subulata, minute pubescentia, corolla alba, minute pubescens, labio superiore oblongo-ovato, emarginato, inferiore trilobo, lobis ovatis, subobtusis; capsulae complanatae, stipitatae, minute et parce pubescentes; semina pallide brunnea, papillosa.

Suffrutescent herb up to 60 cm high; stems terete, pubescent in two lines;

leaf blades elliptic to broadly lanceolate, up to 6 cm long and 3.5 cm wide, acuminate (the tip blunt), rounded at base, thin, entire, glabrous except upon the costa and lateral veins, these minutely and inconspicuously pubescent with curved hairs; petioles slender, up to 4 cm long, glabrous or the grooves pubescent; flowers borne in terminal and axillary spikes up to 5 cm long; bracts, bractlets, and calyx segments filiform-subulate, about 1.5 cm

Fig. 7.—*Streblacanthus parviflorus* Leonard *a*, Portion of plant, natural size; *b*, bract; *c*, calyx segment, *d*, pistil (*b*, *c*, *d*, twice natural size.)

long, the bracts 1 5 mm wide at the base, the bractlets 0 5 mm wide, the calyx segments 1 mm wide, all 3-nerved, sparingly and minutely pubescent; corolla white, 17 mm long, minutely pubescent, the tube slender from base to middle, about 1 mm in diameter, the upper half obconic, 3.5 mm in diameter at mouth, the limb slightly 2-lipped, the upper lip oblong-ovate, 3 mm wide at base, emarginate, the lower lip 3-lobed, the lobes ovate, 4 mm long and 2.5 mm wide, subobtuse; anthers 2 mm long, 1 mm wide; style 6 mm long, glabrous; capsule 12 mm long, flattened, stipitate, 4 mm wide, 4-seeded, minutely and inconspicuously pubescent, the hairs spreading; seeds flat, light brown, 4 mm in diameter, minutely alveolate, roughened by short papillae.

Type in the herbarium of the Field Museum of Natural History, no. 990984, collected at Escoba, across the bay (west) from Puerto Barrios, Department Izabal, Guatemala, in a wet forest near sea level, May 3, 1939, by Paul C. Standley (no 72949). Duplicate in U. S. National Herbarium, no. 1780245.

Streblacanthus parviflorus is related to *S. cordatus*, a species apparently limited to Panamá The calyx, bracts, and bractlets are similar in both species, but in *S. cordatus* the flowers are much longer and larger and the leaves are strongly cordate.

ORNITHOLOGY.—*Remarks on the Kentish plovers of the Extreme Orient, with separation of a new subspecies*.[1]   H. G. DEIGNAN, U. S. National Museum. (Communicated by HERBERT FRIEDMANN.)

In ascertaining which forms of the Kentish plover (*Charadrius alexandrinus*) occur in winter in the Indo-Chinese countries, I have found it necessary to review the extensive material of this species from eastern Asia in the U. S. National Museum and have arrived at conclusions rather at variance from those of the most recent revisers.

Their treatment has recognized two races in the Far East: (1) *dealbatus* of Swinhoe, a long-billed bird, described from South China (type specimen from Amoy, *not* Hainan) and believed to breed in Japan, the Ryu Kyu Islands, in Formosa, Hainan, and on the Chinese coasts from Fukien to Chihli, and to winter in the Indo-Chinese countries and Malaysia; (2) *alexandrinus* of Linnaeus, a short-billed bird, described from Egypt and believed to breed from England across northern Asia to Korea, and to winter in Africa and all tropical Asia.

A good series of birds from Amoy (June, July) are decidedly paler than birds from Europe, have a longer and more massive bill, and in every case have the upperparts suffused with rufous. Swinhoe's description of *dealbatus* as a "washed-out," rufescent-tinged *alexandrinus* fits these specimens perfectly. Another series of badly worn birds from Chihli (July) are probably *dealbatus*. In addition, I have seen examples of this race from Hongkong (October, November) and Hainan (March).

Two birds from Thailand (November, March) and two from Malaya (December), all in winter dress, are so remarkably pale above that they stand out from all other Old World specimens I have seen and can fairly be compared only with *nivosus* and *tenuirostris* of North America. However, the wing length and size of bill are like

those of *dealbatus*, and for the present I take them to represent merely a plumage phase of that form. If this surmise be correct, they are the only specimens of *dealbatus* I have seen from any locality outside of China.

A series of birds from Japan (January, March, April, May), some of which are in full nuptial plumage, have the upperparts without the least rufescent wash and quite as dark as European specimens but differ from the latter in having the bill as long and as massive as *dealbatus*. For the resident bird of Japan, I propose the name **Charadrius alexandrinus nihonensis** subsp. nov., with the type specimen an adult male, U.S.N.M. no. 95938, taken at Aomori, Hondo, April 23, 1876, by Capt. T. W. Blakiston.

Birds of the Asiatic mainland north of the range of *dealbatus* are dark-backed and have the bill somewhat smaller than *nihonensis* but nevertheless larger than *alexandrinus*. There is no doubt an imperceptible change from *nihonensis* to *alexandrinus*, and without series of breeding birds from Siberia and Mongolia a convenient geographic line of demarcation between the two can not be decided upon.

There is a certain amount of normal variation in bill size in any given form of this species, and younger birds tend to have shorter bills than their parents. However, even the shortest-billed examples from the Pacific coasts of Asia have the bill rather more massive than European birds of corresponding age and sex—a difference that must be seen to be appreciated—and are thus better called *nihonensis*. Specimens either inseparable from Japanese birds or nearer them than *alexandrinus* have been examined from Korea (December), Kiangsu (January, March, April), Chekiang (February), Fukien (October, November, January), Hongkong (October), Hainan (October), Luzon (February, March), Cebu (November), Siquijor (February), Jolo (March), Thailand (November, May), and Malaya (December).

The easternmost birds seen that, in my opinion, may more or less safely be called *alexandrinus* are two specimens from Szechwan (December) and six from northwestern Thailand (October, November, January).

The recent discovery of a resident form of the Kentish plover on the Island of Java (*Charadrius alexandrinus javanicus* Chasen) confirms the correctness of the opinion expressed by Peters as to the specific distinctness of *Charadrius peronii*. As Chasen observes (1938) that he has seen no true *peronii* from Java, it may be well to note that the U. S. National Museum has an adult pair, taken in the Province of Bantam by O. Bryant in December, 1909.

Charadrius peronii is already known to occur on the eastern coast of the Malay Peninsula as far north as the Sam Roi Yot district of southwestern Thailand. What appears to be the first record for this species from the opposite side of the Gulf of Siam is an adult male (one of a pair seen) with enlarged gonads, collected by me near Chanthabun, southeastern Thailand, on May 7, 1937.

ENTOMOLOGY.—*Two new species of coccinellid beetles from Costa Rica and Colombia.*[1] EDWARD A. CHAPIN, U. S. National Museum.

The descriptions of two synonychine Coccinellidae are here offered in order that their names may be available for use in the literature of economic entomology. One of the species was submitted by Dr. Luis María Murillo, who reports that it was taken on apple at Bogotá, Colombia; the other has been collected repeatedly in Costa Rica, sometimes associated with avocado. Both species are somewhat aberrant, and the generic assignment of the *Cycloneda* may eventually have to be changed.

Cycloneda costaricae n. sp.

Similar in form but larger than *C. sallei* (Muls.) and with two subbasal spots on each elytron instead of a single humeral spot as in that species. The genital structures are also distinct from all species known to the writer.

Body pale except that the metasternum is more or less deep piceous. Head pale yellowish, without maculation in either sex. Pronotum pale yellowish, with the six spots of deep piceous, almost black. Two of the spots are basal and roughly triangular and divide the base into nearly equal thirds; two are discal, somewhat oval and separated by less than the transverse diameter of either; two are lateral, nearly round and each distant from the lateral margin by less than its own diameter. Scutellum black. Elytra with a narrow elongate spot at the scutellum and a second narrowly oval spot at apical third common to both. In addition to the spots common to both, each elytron bears eight blackish spots as follows: Two subbasal placed on either side of the humeral callus, separated one from the other by about one-third of the diameter of either and each separated from the adjacent margins of the elytron by nearly its diameter; three subquadrate spots in a transverse row just before the middle of the elytron, the sutural spot being slightly less advanced than the others; two at apical third, each subcircular and slightly smaller than any of the preceding row, forming with the common sutural spot a nearly straight transverse row and finally a single subapical spot, larger than any of the others and slightly closer to the margins of the elytron. Legs and other appendages pale. Aedeagus with slender median lobe which is bifurcate at apex and with slender, hooked parameres (Fig. 1). Receptaculum seminis slender, hooked, duct entering through a side chamber; duct sclerotized, simple, straight and slender (Fig. 2). Length: 4.5 to 6 mm.

Type and five paratypes.—U. S. N. M. no. 54927

Type locality.—Costa Rica, San José (San Pedro de Montes de Oca).

Material examined.—Type (male) and two paratypes taken at the type locality December 5, 1932, and January 20, 1933, by C. H. Ballou (Ballou no CR 40); one paratype from San José, July 12, 1931, one from Coronado, May 24, 1925, and one from Curridabat, December 30, 1924, all taken by Ferd. Nevermann

Remarks.—This species has been in the past confused with *C. sallei* (Muls.), and it is very probable that the Costa Rican record of *sallei* in the Junk-Schenkling (Korschefsky) Catalog should be crossed out. The record is apparently based on the San José (Nevermann) paratype, which carries Korschefsky's identification label. Through the kindness of Gaston Vivas-Berthier, the national collection now contains a specimen of the true *C.*
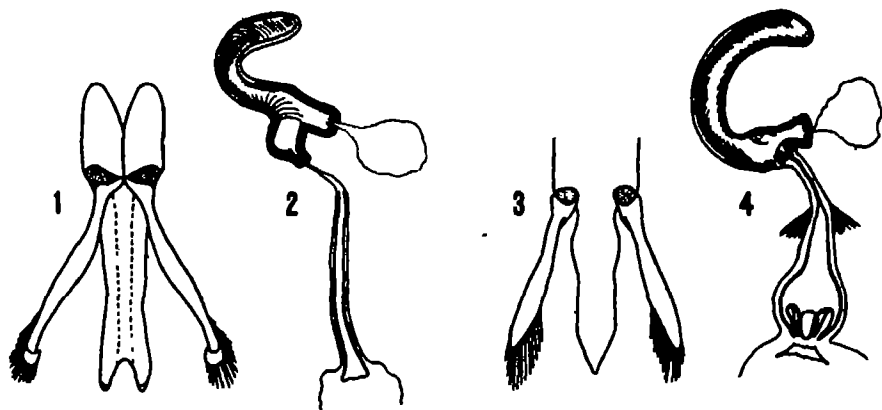
Figs 1-2 —*Cycloneda costaricae* n sp : 1, Aedeagus; 2, receptaculum seminis and duct   Figs 3-4 —*Neda murilloi* n sp : 3, Aedeagus; 4, receptaculum seminis and duct

sallei, taken by him at or very near the type locality, given by Mulsant as "environs de Caracas "

Neda murilloi n. sp.

Similar in form and size to *N. amandi* Muls. from which it differs in having a conspicuous apical elytral spot and in the genital structures of both sexes.

Body and appendages (except elytra) deep piceous black. Head rather coarsely and densely punctured, hairy, black. Pronotum transverse, very little more than half as wide as the combined elytra at widest point, black with a quadrate pale spot in each anterior angle, surface finely and densely punctured, glabrous. Scutellum black. Elytra pale yellowish white with sutural and lateral margins very finely margined with black. In addition, there is a transverse oval spot across suture at basal third and a nearly circular spot across suture at apical third. Further, there is a longitudinal row of four spots as follows: a nearly circular spot on humeral callus, a subtriangular spot just beyond basal third, a small spot at apical third which joins the second sutural spot and an apical spot joining the lateral margin. There are also two subquadrate spots joining the lateral margin, one at basal third, the second at apical third. Aedaegus with median lobe acuminate, para-

meres straight and slender (Fig. 3). Receptaculum seminis of female slender, C-shaped, duct sclerotized, flask-shaped (Fig. 4). Length: 9 mm.

Type and paratype.—U. S. N. M. no 54928

Type locality.—Colombia: Bogotá

Material examined.—Two specimens, a male (type) and a female, taken on apple tree by Dr. Luis M. Murillo (Murillo no. 46).

Remarks.—This interesting species closely resembles at first glance *Neda amandi* Muls. but differs from any of the color forms of this species by the presence of the well-defined semicircular apical spot. But of much more importance is the fact that the genital structures of both sexes are very aberrant for the genus. *N. murilloi* is the only species of the genus known to the author having the median lobe of the aedaegus acuminate or having such a complicated sclerotization of the duct connecting the bursa and receptaculum in the female. Unfortunately the basal piece of the aedeagus was injured at the time of dissection and cannot be described or figured. The writer takes pleasure in naming this species in honor of Sr. Dr Luis María Murillo, director of the Department of Entomology of the National University at Bogotá.

ICHTHYOLOGY.—*Pluralité spécifique du genre* Pegusa [*Pleuronectoidea Soleiformes*].[1] PAUL CHABANAUD, Muséum National d'Histoire Naturelle, Paris. (Communicated by AUSTIN H CLARK and LEONARD P. SCHULTZ.)

En 1929,[2] examen fait de quelque 125 spécimens, j'ai cru bon de réunir sous un seul et même nom d'espèce, *Pegusa lascaris*, tous les Soleidae dont les caractères morphologiques répondent à la définition du genre *Pegusa* Günther 1862[3] à savoir: *Pleuronectes lascaris* Risso 1810,[4] *Pleuronectes nasutus* Pallas 1811, *Pleuronectes solea* var. c Nardo 1924, *Solea pegusa* Yarrell 1829, *Solea impar* Bennett 1831, *Solea scriba* Valenciennes 1835, *Pleuronectes nasutus* Rathke 1837, *Solea brasiliensis* Kaup 1858 (= *Solea kaupi* Berg 1895), *Solea aurantiaca* Günther 1862, *Solea margaritifera* Günther 1862, *Solea triophthalmus* Bleeker 1863, et *Solea vermeuleni* Metzelaar 1919. À l'exception de *Pleuronectes nasutus* Rathke (si ce n'est un paratype de *Solea nasuta* Nordmann 1840), à l'exception également de toutes celles dont la description a été publiée avant l'année 1831, j'ai eu sous les yeux le type même d'après lequel ont été rédigées ces diverses diagnoses.[5]

Nonobstant certaines différences dont il sera question plus loin, tous les individus examinés présentent un faciès qui, dans son ensemble, demeure identique: forte proéminence du museau; insertion du 1ᵉʳ rayon notoptérygien au niveau de l'oeil migrateur, lequel est situé tout entier au-dessous du niveau de la ligne latérale cœliocercique; yeux conservant un contour circulaire, même lorsqu'ils ne sont pas exsertés; fausse paupière énantique non squameuse, d'où la possibilité de la délimitation de l'aire squameuse interoculaire, ainsi que de la mesure pratiquement exacte de la largeur de cette aire squameuse, dite "espace interoculaire"[6]; constance de la position et de la structure des narines, tant nadirales que zénithales;[7] dissimulation complète de la commissure maxillo-mandibulaire zénithale par le revêtement cutané; grand développement des lèvres mandibulares, notamment de la zénithale, qui, nullement ciliée, se replie sur elle-même extérieurement; constance de la forme du clidoste.[8] Les cretules intercanaliculaires des écailles sont entières, pour la plupart, mais très irrégulières et fortement onduleuses, manifestant un début de fragmentation en éléments disto-convexes.

Ceux des caractères morphologiques qui sont couramment utilisés en ichthyologie se montrent toutefois susceptibles d'une variabilité particulièrement étendue: S 95 à 140. D 60 à 90. A 52 à 75. P z 7 à 10. P n 7 à 10. V z 5. V n 5.

Compté sur 20 individus,[9] le nombre total des vertèbres oscille entre 42 et 48, mais seul diffère le nombre des vertèbres caudales, car celui des vertèbres abdominales a été trouvé constamment réduit à 9, sauf chez un seul spécimen, originaire de Douarnenez, qui a, pour formule rhachiméristique, a 10 $[5+5]+c$ 37 $= t$ 47.

Envisagé de la sorte, *Pegusa lascaris* jouit d'une géonémie extrêmement vaste, puisqu'elle s'étend de la mer du Nord au cap de Bonne-

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tion politique qui pèse actuellement sur l'Europe me mette dans l'impossibilité de revoir les spécimens que ne possède pas le Muséum National d'Histoire Naturelle Force m'est donc, en ce qui les concerne, de me contenter de mes notes manuscrites, sans autre examen direct que celui d'écailles montées entre lame et lamelle et que, par bonheur, j'ai conservées par devers moi

[6] Mesure impracticable lorsque la fausse paupière énantique est squameuse et, par son développement, confère à l'oeil non exserté un contour longitudinalement elliptique Genres *Monochirus* Rafinesque 1814, *Microchirus* [Bonaparte 1832] Chabanaud 1938, *Bathysolea* Roule 1916, *Dicologlossa* Chabanaud 1927, *Solea* Quensel 1806, et *Buglossidium* Chabanaud 1930.

[7] Structure maintes fois décrite et figurée Cfr. Chabanaud, Bull Inst. Océan. 488: 44, 48 1927, Ann. Inst Ocean 7: 231 et seq, fig 21. 1929; Bull Inst. Ocean. 555: p 6 1930.

[8] Ann Inst Océan, t. cit, le scripti 30, 31, et 32; tab. 2, le 1 et 2

[9] Ann. Inst Océan, t. cit, p. 252. Aux 16 spécimens mentionnés à cette place s'ajoute celui dont la cathodographie fait l'objet de la fig 2 de la planche 2 de ce même travail Par la suite, les vertèbres de 3 autres spécimens ont été comptées.

Espérance et même à la côte du Natal,[10] comprenant, avec la Manche
(et la mer d'Irlande?) et la totalité de l'Atlantique oriental, au sud des
iles Britanniques, la Méditerranée tout entière, l'Adriatique, la mer de
Marmara et la mer Noire.

Or il s'agit en réalité d'une espèce composite. *Pegusa triophthalmus*
[Bleeker 1863] s'isole de l'ensemble par la dimension plus grande et
corrélativement par le nombre plus réduit de ses écailles, par la forme
de celles-ci, mais surtout par celle des nadirales, enfin par le dévelop-
pement réduit de la membrane postradiaire terminale des deux
nageoires impaires précèdant l'uroptérygie. Ces différences n'ont pas
été remarquées par Bleeker, qui, à propos de la pholidose, se contente
de cette mention: "squamis utroque ctenoidis"; elles m'avaient
échappé jusqu'ici. Pour autant que je puisse l'affirmer, d'après l'exa-
men de 3 spécimens, y compris l'holotype, ce qui, de ce chef, caracté-
rise *Pegusa triophthalmus* s'allie constamment à la présence de 3 taches
noires zénithales, qui sont à l'origine du nom que porte l'espèce.

Les descriptions suivantes permettront de distinguer l'un de l'autre,
malgré leur étroite ressemblance, *Pegusa triophthalmus* et *Pegusa las-
caris*.

### Pegusa triophthalmus (Bleeker 1863)   Figs. 1, 3-5

S 95–105 D 76-80 A 52–64. C (19) 20 P z 9 P n (7) 9 V z 5. V n 5

Les écailles zénithales sont longuement rectangulaires; leurs bords latéraux
sont subrectilignes et leurs 4 angles sont bien marqués Le nucleus n'est
qu'à peine plus rapproché du bord proximale que ne le sont les angles dis-
taux Mesurée entre les angles distaux, la longueur du bouquet de spinules
égale presque la largeur moyenne du pholidoplaxe Les spinules sont très
nombreuses; on en compte jusqu'à 30 marginales La longueur de celle-ci
est relativement faible et n'augmente que modérément des spinules latérales
à la spinule médiane, de telle sorte que l'ensemble de leurs pointes dessine
une courbe large et régulière.

Les écailles nadirales sont plus courtes que les zénithales correspondantes,
leurs bords latéraux présentent une convexité qui va s'intensifiant des angles
proximaux aux angles distaux. Ces derniers se rapprochent considérablement
l'un de l'autre, réduisant la largeur du bouquet de spinules à moins du
quart de la largeur maximale du pholidoplaxe. Le bouquet de spinules
s'enfonce très profondément dans le pholidoplaxe, atteignant une longueur
au moins égale à sa propre largeur; ainsi le nucleus ne se trouve-t-il séparé du
bord proximale du phanère que par une distance beaucoup plus courte que
celle qui existe entre ce même bord proximale et les angles distaux Les
spinules sont presque rudimentaires et c'est à peine si les marginales se
prolongent au'delà du niveau des angles distaux

La thoracoptérygie zénithale mesure des 55 aux 60 centièmes de la lon-
gueur de la tête. La thoracoptérygie nadirale a toujours été trouvée sensible-
ment plus courte que la zénithale et ne mesurant que des 47 aux 51 centièmes
de la même longueur prise comme étalon.

[10] C. VON BONDE, *Rep. Fish Mar. Biol Survey South Africa* 2: 17 (*Solea impar*)
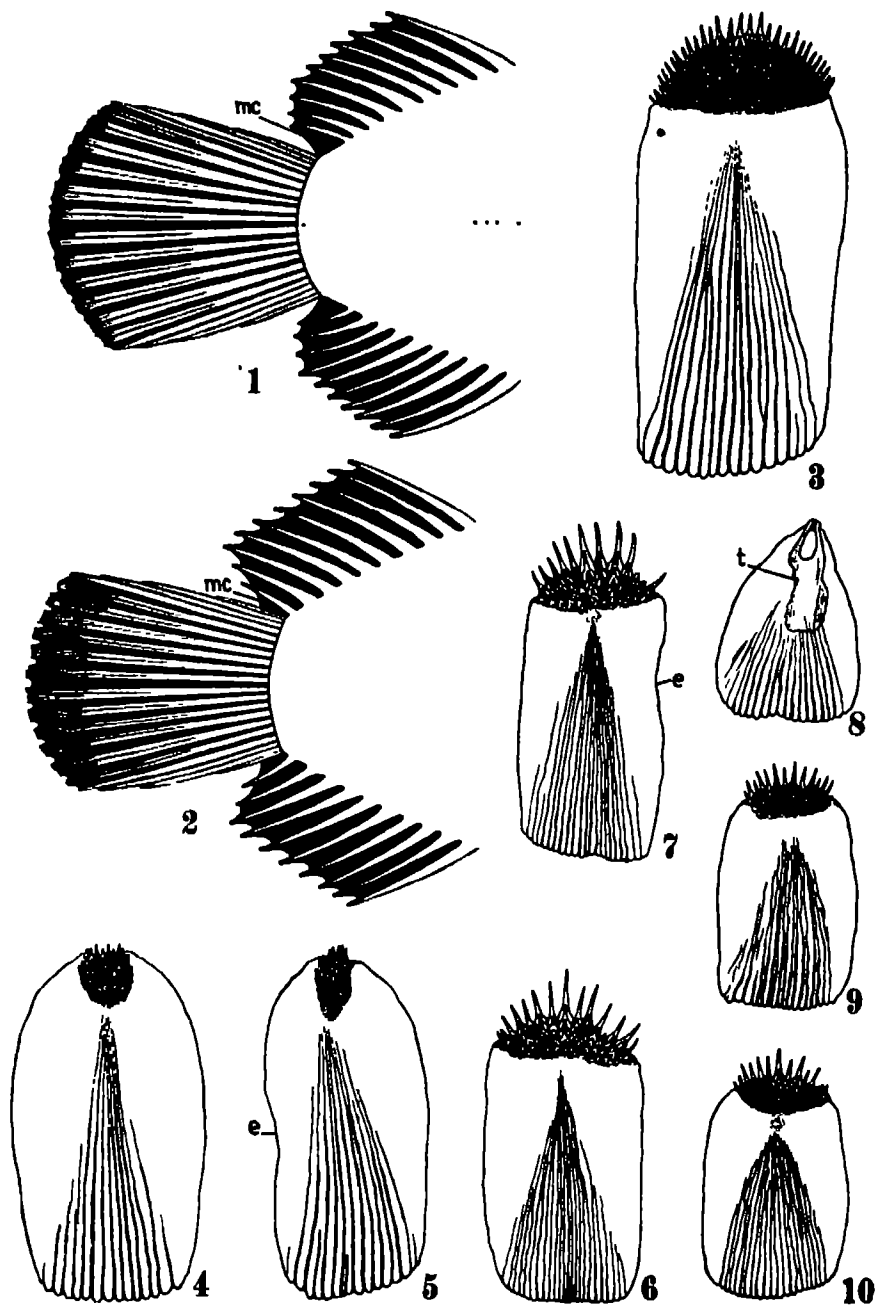
Figs. 1-10 —(See opposite page for explanation)

L'uroptérygie est libre; la membrane postradiaire terminale des deux autres périssoptérygies s'attache à l'extrême base de ses deux rayons marginaux, l'épaxonal et l'hypaxonal.

Le rayon terminal de la notoptérygie et celui de la proctoptérygie s'insèrent respectivement à quelque distance de l'uroptérygie. Les deux rayons marginaux de cette dernière nageoire sont beaucoup plus longs que le rayon terminal de chacune des deux autres perissoptérygies

Deux spécimens, autres que l'holotype, ont respectivement pour formule rhachiméristique: $a\ 9[4+5]+c\ 34 = l\ 43$ et $a\ 9[4+5]+c\ 39 = l\ 48$

L'espèce n'est connue que de la côte occidentale de l'Afrique, entre la Mauritanie et le golfe de Guinée

Pegusa lascaris (Risso 1810)   Figs. 2, 6–10

S 108–140 D 65–90. A 53–75 [11] C (19) 20. P z 8-9 P n 8-9 V z (4) 5. V n (4) 5.

La forme générale des écailles est assez variable. Ces écailles sont rectangulaires, tantôt courtes, larges et à bords latéraux convexes (type de *Solea vermeuleni* Metzelaar), tantôt fortement allongées et à bords latéraux subrectilignes. La distance comprise entre le bord proximal et le nucleus n'est jamais qu'un peu plus courte que la distance qui sépare ce même bord proximal des angles distaux. Mesurée entre les deux angles distaux, la largeur du bouquet de spinules égale presque la largeur moyenne du pholidoplaxe ou, tout au moins, la largeur de celui-ci à ses angles proximaux. Les spinules sont plus robustes et moins nombreuses que chez *Pegusa triophthalmus*: on ne compte guère plus de 15 à 18 marginales La longueur de celles-ci augmente rapidement des deux spinules latérales à la médiane, de telle sorte que la courbe dessinée par l'ensemble de leurs pointes se rapproche davantage de l'ogive que de l'arc de cercle.

Les écailles nadirales sont plus courtes que leurs homologues zénithales, généralement rectangulaires, parfois légèrement trapézoïdales; leurs bords latéraux présentent une convexité plus ou moins prononcée, d'où résulte un certain effacement des angles proximaux, comme des angles distaux. Ces derniers ne sont cependant guère plus rapprochés l'un de l'autre que les angles distaux; aussi, mesurée entre ceux-ci, la largeur du bouquet de spinules demeure-t-elle constamment supérieure à la moitié de la largeur maximale du pholidoplaxe, pouvant même devenir—comme sur la face zénithale—subégale à la largeur moyenne de celui-ci. La distance comprise entre le bord proximal et le nucleus n'est guère plus courte, par rapport à la longueur du pholidoplaxe, mesurée du bord proximal aux angles distaux, que celle qui existe sur les écailles zénithales correspondantes. Les spinules sont en nombre similaire à celui des spinules zénithales; les marginales ne sont qu'à peine moins développées que ces dernières

[11] Les nombres indiqués ici sont ceux que j'ai comptés moi-même Sur des exemplaires de la mer Noire, Nordmann a trouvé. D. 60 et A 52.

Fig 1.—*Pegusa triophthalmus* Schema des nageoires impaires, à l'extrémité postérieure du corps. Fig 2.—*Pegusa lascaris* Schema des nageoires impaires, à l'extrémité postérieure du corps Fig 3.—*Pegusa triophthalmus* Diagramme d'une écaille zénithale libre Fig 4.—*Pegusa triophthalmus* Diagramme d'une écaille nadirale libre Fig. 5.—*Pegusa triophthalmus:* Diagramme d'une écaille nadirale paragrammique (e, emargination du côté énantique). Fig 6.—*Pegusa lascaris* Diagramme d'une écaille zénithale libre. Fig. 7.—*Pegusa lascaris* Diagramme d'une écaille zénithale paragrammique (e, émargination du côté énantique). Fig. 8.—*Pegusa lascaris:* Diagramme d'un écaille zénithale pleurogrammique (t, tube organique) Fig. 9.—*Pegusa lascaris*. Diagramme d'une écaille nadirale libre. Fig 10.—*Pegusa lascaris* Diagramme d'une écaille nadirale libre.

La thoracoptérygie zénithale est proportionnellement un peu plus courte que chez *Pegusa triophthalmus*, ne mesurant que des 38 aux 51 centièmes de la longueur de la tête La thoracoptérygie nadirale atteint fréquemment une longueur égale à celle ce la zénithale; lorsque cette nageoire nadirale est plus courte que son homologue zénithale, la différence reste légère

La membrane postradiaire terminale de la notoptérygie s'attache plus ou moins largement au rayon marginal concomitant de l'uroptérygie et il en est de même pour la membrane postradiaire de la proctoptérygie.

Le rayon terminale de la notoptérygie et celui de la protoptérygie s'insèrent respectivement contre le rayon marginal concomitant de l'uroptérygie La longueur des deux rayons marginaux de l'uroptérygie n'excède pas, ou seulement fort peu, celle de rayon des deux autres perissoptérygies.

La formule rhachiméristique la plus basse qui ait été enregistrée se chiffre par a 9[4+5]+c 33·=t 42 Les formules les plus hautes se chiffrent par a 9[4+5]+c 38 = t 47 et par a 10[5+5]+c 37 =t 47 Compté sur 4 spécimens, le nombre total des vertèbres est de 42 et 43, dans la Mer Noire D'après 4 observations, ce nombre oscille entre 42 et 45 dans la Méditerranée occidentale. Dans l'Atlantique, entre la Manche et l'Angola, ce même nombre oscille entre 45 et 47 (7 observations) Enfin, 2 spécimens d'origine indéterminée, mais qui proviennent vraisemblablement de la Manche (marché de Paris), possèdent 47 vertèbres.

A cause de sa grande variabilité morphologique, *Pegusa lascaris*, dans l'immense étendue de son habitat, semble justiciable d'un démembrement en nations ou en sous-espèces locales, dont seule l'étude approfondie d'une quantité considérable d'individus permettrait de préciser les caractères

Explication des figures.—Toute les écailles qui font l'objet des figures 3 à 10 ont été prélevées sur la partie moyenne du coeliocerque (région abdomino-caudale); les écailles dites "libres," à 2 ou 3 rangées au-dessus ou au-dessous de la ligne latérale. Celles de ces écaille qui sont prises comme témoins de la pholidose de *Pegusa triophthalmus* (figs. 3, 4, et 5), proviennent d'un spècimen male, de 206 millimètres de longueur totale et de 177 millimètres de longueur étalon, capturé en 1935, devant Bathurst, par le navire belge *Mercator*. Celles qui sont données comme examples de la pholidose de *Pegusa lascaris* (figs. 6 à 10) proviennent d'un spécimen male, de 248 millimètres de longueur totale et de 216 millimètres de longueur étalon, capture par le même navire et dans la même localité. Ces deux spécimens appartiennent au Musée Royal d'Histoire Naturelle de Belgique (Bruxelles).

HERPETOLOGY.—*A new genus of Central American snakes related to* TANTILLA.[1] HOBART M. SMITH.[2] (Communicated by HERBERT FRIEDMANN.)

The peculiar character of the teeth of certain members of the genus *Tantilla* (*brevissima, lintoni*) has been observed previously.[3] At the time the observations were made, it was not possible to determine whether the more generalized condition obtaining in these two species was the rule for Central and South American species of the genus, or whether other species might not show as less significant the apparently great difference between the two types of dentition. Representatives of most of the important species groups of the United States and Mexico were then examined, but no members of the several distinctly different groups of Central and South American species.

Since then I have been able to examine maxillae of most other species groups of the genus, including *canula, melanocephala, moesta, vermiformis*, and a species related to *taeniata*, all from Central and South America. A few more Mexican and United States species and subspecies that were not previously examined were also checked.

With the exception of *brevissima* and *lintoni*, the dentition of the maxilla holds to a rather well defined pattern, with relatively little variation. Invariably the teeth are flattened at the tips, and those anterior to the fangs are of subequal length. Two grooved fangs terminate the tooth series. The grooves are very well defined and the fangs sharply differentiated from the other teeth by their much larger size. Usually a small diastema precedes the fangs, but in some species there definitely is no diastema. Also the fangs are usually slightly or distinctly offset from the line of the other teeth, but this is definitely not the case in *canula* and *calamarina*, and in some others the extent of offsetting is negligible. There is no correlation between size of diastema and extent of offsetting of the fangs. The number of teeth, including fangs, varies between 12 and 19. *T. calamarina* has 12 (checked in two specimens); *atriceps, bocourti, nigriceps*, and a species related to *eiseni* have 13; *wilcoxi, fumiceps*, and *vermiformis*, 14; *eiseni, gracilis, canula*, and *miniata*, 15; *coronata, wagneri*, and *moesta*, 16; species related to *taeniata*, 17; and *melanocephala*, 17. Obviously there is no possibility of tracing relationships by number of teeth, for close relatives may differ considerably, and likewise species distantly related may have the same number of teeth. It is easily possible, how-

ever, that in case an intensive study were undertaken, the average
number of teeth in a series of specimens of a species would show some
significance in comparison with the average numbers of other species.
Intraspecific variation was noted in *bocourti* (some have 10+2, others
11+2, others 12+2 teeth) and certain other species, and very likely
occurs to a comparable extent in all species of the genus.

The two species most closely approaching the condition occurring
in *lintoni* and *brevissima* are *calamarina* and *canula*. In these the dif-
ference in size between fangs and the other teeth is less than in other
species. In *calamarina* the fangs are one and one-half times as long as
the other teeth but are larger at the base, broader throughout their
length, and appear at least twice the size of the preceding teeth. The
grooves are very plain and deep. In *canula* the fangs are twice as long
as the other teeth, deeply grooved, but their bases are not greatly
larger, and accordingly their size is little more than twice that of the
others.

In total number of maxillary teeth, *melanocephala*, the southern-
most species of the genus, is the closest to *brevissima* and *lintoni*, but
there is no close relationship to them, for the fangs are very large,
offset, deeply grooved, and preceded by a diastema.

In *brevissima* and *lintoni* the rear teeth are not offset from the
others, and there is no diastema whatever. In *lintoni*, there is abso-
lutely no difference between the rear teeth and the others, either in
size or grooving. Furthermore, the teeth do not exhibit the flattened
condition (at the tip) obtaining in other species, but are thick
throughout their length, with dull points. Finally, the teeth number
23 on one side, 25 on the other—considerably more than in other
members of the genus.

T. brevissima is essentially similar to *lintoni*, but exhibits certain
differences which show close relationship to other species of *Tantilla*.
The rear teeth (presumably two, the extreme posterior tooth missing
from its socket, but assumed to be similar to the tooth preceding) are
visibly enlarged, perhaps one and one-third times as long as the
others, their bases slightly larger, but their size apparently less than
twice that of the other teeth. Otherwise, the rear teeth are exactly
like the remainder, so far as I can see. They are somewhat rounded,
with no evidence of grooves. The teeth preceding these are somewhat
flattened at the tips, essentially similar to the teeth of other *Tantilla*.
Finally, the total maxillary tooth count is 22.

Despite certain differences between the dentition of *brevissima* and
lintoni, the two species are best associated together, since both have

ungrooved posterior teeth, and a considerably greater number of teeth than any other of the genus. It is possible that *Tantilla brevis* (which I have not seen) has similar dentition, but I think no other can be linked with these.

Because of the differences exhibited by these two species, it appears that they are best segregated from *Tantilla*. They are placed in

Tantillita gen. nov.

Diagnosis.—Hypapophyses absent in posterior part of vertebral column; scales in 15 rows, smooth, without apical pits; scales of head normal, except temporals 1+1, and no loreal; teeth on maxilla number 22 to 25, about equal in size, posterior teeth not at all or but slightly enlarged, not grooved, head somewhat flattened; size small; tail relatively short

Genotype — *Tantilla lintoni* Smith, Proc. Biol. Soc. Washington **53**: 61–62, fig. 1. 1940. (Piedras Negras, Guatemala).

Referred species — *Tantilla brevissima* Taylor, Trans Kansas Acad Sci **39**: 344–345, fig. 4 1936 (1937) (Tonalá, Chiapas).

HERPETOLOGY.—*Notes on snakes of the genus* Conophis.[1] HOBART
    M. SMITH.   (Communicated by HERBERT FRIEDMANN.)

The identification of a specimen related to *Conophis lineatus* from Chiapas, Mexico, has led to a review of available material of that genus from Central America and Mexico.

While all the members of the genus are pretty closely related, two major divisons are discernible. One contains *vittatus* (with its subspecies *viduus*) and is characterized by (1) the presence normally of seven supralabials and (2) the absence of pigment on the supralabial border, chin, ventrals, and first scale row. The second major division contains *lineatus* and *pulcher* and is characterized by (1) the presence normally of eight supralabials and (2) pigmentation on the supralabial border, chin, ends of ventrals (usually), and on the first scale row.

The subdivisions within the second division are, of course, specific, as there are only two species. One species (*pulcher*, with its subspecies *plagosus*) is characterized by (1) a well-defined color pattern, with 10 stripes at least posteriorly, the median pair on the paravertebral rows; and (2) presence of a dark stripe (actually the edge of the dorsolateral stripe) on (including) the second scale row on all the body (except neck). The second species (*lineatus*) is characterized by (1) less well defined stripes, some or all tending to become obsolete; no stripes or indication of stripes on the paravertebral rows on any part of the body; pattern essentially of six stripes; and (2) the second scale

row free of stripes at least anteriorly, at no place involved by dorso-
lateral stripes. The following key contrasts certain differences be-
tween the various forms of the genus:

<center>KEY TO RACES OF CONOPHIS</center>

1. First scale row not pigmented on any part of body; chin and labial border
   white, usually seven supralabials . . .2
   First scale row pigmented on part or all of body; chin and labial border
   pigmented; usually eight supralabials . . 3
2 Four dark stripes posteriorly, the median pair separated by one and two
   half scale rows *vittatus vittatus*
   Three dark stripes posteriorly; if a light median area is present in median
   dark stripe, it is less than one scale row in width *vittatus viduus*
3 Dorsolateral dark stripe *which passes through eye* involving upper half of
   second scale row, a dark stripe on paravertebral scale rows, at least
   posteriorly . 4
   Dorsolateral dark stripe which passes through eye becoming indistinct
   on body, or restricted to fourth or third and fourth rows, not involving
   second row, no stripes on paravertebral rows on any part of body 5
4. Ends of ventrals with some indication of spots on some part of body;
   paravertebral stripes continuous posteriorly; other primary stripes not
   spotted in appearance; markings on chin and labial borders distinct
   pulcher pulcher
   Ventrals completely unpigmented, paravertebral stripes not continuous
   on any part of body; other primary stripes spotted in appearance;
   markings on chin and labial borders dim *pulcher plagosus*
5 Stripes disappearing on nape, not or but faintly visible posteriorly
   lineatus concolor
   Stripes visible throughout length of body 6
6 Dorsolateral stripes becoming extremely narrow on nape, restricted to
   fourth scale row *lineatus lineatus*
   Dorsolateral stripes involving adjacent portions of the third and fourth
   scale rows *lineatus similis*

The various patterns of *pulcher* and *lineatus* are obviously derived
from one similar to that of *viduus*, which I believe is nearest the
ancestral type of the genus. It is rather difficult to discern whether
pulcher or *lineatus* is the more primitive, but I have concluded that
the former probably is, since the pattern of the latter seems to be re-
duction, not from the *viduus* type, but from the *pulcher* type. Reduc-
tion of the latter pattern type in *lineatus* took place in three directions,
concolor becoming the most strongly modified, *l. lineatus* and *l. similis*
changing the least. In fact, although the latter two are separated from
each other by *l. concolor* and *p. pulcher*, they resemble each other
closely. I believe these two might be given as examples of parallel
evolution: both (likewise *concolor*) started on the same trend—toward
loss of the stripes by both vertical and longitudinal breaking; and the
two have now reached nearly the same stage in that process, although

widely separated geographically. Why *concolor* should have proceeded along the same trend so much more rapidly than either *l. lineatus* or *l. similis* is not readily obvious. The most apparent possibility is that it was isolated from the other stock during some geologic period, while the evolution of the other two was retarded through influence of the ancient *pulcher* stock, which apparently has no evolutionary trend toward loss of stripes.

Conophis vittatus vittatus Peters

Conophis vittatus Peters, Monatsb Akad Wiss. Berlin, 1860: 519 520, pl ,
   fig. 3 (type locality not known).—Smith, Field Mus. Nat. Hist Zool Ser.
   24: 31. 1939 (type locality restricted to Acapulco, Guerrero).
Conophis sumichrasti sumichrasti Cope (part), Journ Acad Nat. Sci. Phila-
   delphia, (2), 8: 137. 1876 (type locality, Tehuantepec and Guadalajara)
   —Smith, Field Mus. Nat. Hist Zool Ser. 24: 31 1939 (type locality er-
   roneously restricted to Tehuantepec).

Diagnosis —Chin and labial borders white, not pigmented; usually seven supralabials; first scale row not pigmented; four dark stripes on posterior part of body, the lateral stripes covering less than two scale rows, the me- dian pair separated by a light middorsal area one and two half scale rows wide.

Distribution —Guerrero south into Oaxaca avoiding areas of considerable elevation

Specimens examined —Five, U. S N. M no 29123, Guadalajara, Jalisco, U S. N. M nos 31394–7, Colima.

Remarks —*Conophis sumichrasti sumichrasti* was described on the basis of one specimen from "the western part of Tehuantepec" (U S N. M no. 30258) and another from Guadalajara, Jalisco (U S. N M no 29123) The type locality was restricted to Tehuantepec by me (*loc cit*), but this can not stand, for Cope's very brief diagnosis does not apply to the Tehuan- tepec cotype, but rather to the Guadalajara cotype Cope says "second row not covered by lateral band, dorsal bands distinct" for *sumichrasti*. In the Tehuantepec specimen the lateral band does involve the second scale row, and the dorsal bands are scarcely distinct (certainly not as much so as in the Guadalajara specimen, which is typical *vittatus*) Accordingly I designate the Guadalajara specimen, to which Cope's diagnosis of *sumichrasti* refers, as lectotype

The Tehuantepec cotype of *sumichrasti* is not exactly typical of *viduus* but is much nearer it than to typical *vittatus*, if I correctly interpret the rela- tive importance of difference between the two subspecies. The differences appear to be two, both in pattern: (1) *In viduus* the median dark stripe is single, covering about three and two half scale rows; if divided, the median light line is faint and narrow, of less than one scale width; in typical *vittatus* the median dark stripe is double, with the middorsal white area covering about one and two half scale rows; in this the whole median stripe (including the middorsal white stripe and the adjacent dark stripes on each side) covers

five and two half scale rows, while in *viduus* it covers a maximum of three and two half (or three-quarters) scale rows. (2) In *viduus* the lateral stripe is broader, anteriorly covering all of two, and parts of the adjacent, scale rows; in typical *vittatus* it covers less than two whole scale rows.

The cotype of *sumichrasti* agrees more nearly with typical *vittatus* in the character of the lateral stripe, which anteriorly covers a little less than two scale rows. However, the median stripe is not widely divided as in typical *vittatus* but agrees in condition with that shown by three other specimens from Tehuantepec, secured by me, in the National Museum. In these a narrow light stripe, beginning anteriorly shortly behind the neck, or first appearing nearly as far back as the middle of the body, is present on the middorsal scale row, and disappears at the base of the tail. The light stripe is less than a scale row wide. In all these the entire median stripe is three and two half scale rows wide, as in *viduus* with a uniform middorsal stripe.

I believe that the character of the middorsal stripe is of greater significance than that of the lateral and accordingly refer the cotype of *sumichrasti* to the synonymy of *viduus*. However, the intermediate condition shown by the cotype and the other specimens mentioned above rather strongly indicates that there may be intergradation between these two. The fact that the cotype of *sumichrasti*, which presumably comes from farther west (and nearer the known range of typical *vittatus*) than my specimens, approaches more closely to the characters of *vittatus* than specimens from near Tehuantepec, lends support to the belief that the two forms intergrade.

The identity of the type of *vittatus* is fortunately fixed by Bocourt, who published excellent illustrations of it (Mission Sci. Mex., Rept., pl. 38, fig. 7. 1886). The type is not from Tehuantepec, however, as inferred by Bocourt.

It is apparent that Cope considered the name of *vittatus* applicable to quite a different species than Peters described, as indicated in his check list (U. S. Nat. Mus Bull. **32**: 76 1887), in which he lists a specimen from Guatemala, collected by Dow. This is an intergrade between *concolor* and apparently *lineatus* If this is what Cope interpreted as *vittatus*, it is apparent why he described *sumichrasti*.

Conophis vittatus viduus Cope

Conophis sumichrasti viduus Cope, Journ. Acad. Nat. Sci. Philadelphia (2) **8**: 137   1876 (type, U S N. M. no. 30259); Tehuantepec
Conophis sumichrasti sumichrasti Cope (part), *loc. cit*, (the Tehuantepec specimen).

Diagnosis —Chin and labial borders white, not pigmented; usually seven supralabials; first scale row not pigmented; three dark stripes, the lateral more than the equivalent of two full scale rows in width, the median involving three and two half scale rows; sometimes a narrow light stripe, less than one scale row in width, extending down part of vertebral scale row, but in this case the entire median stripe is no wider than in other specimens.

Distribution.—Area about Tehuantepec, Oaxaca.

Specimens examined.—Nine, U S. N M nos. 30258-9, 109709-14; one in the EHT-HMS collection.

Remarks.—See remarks under *vittatus vittatus.* The type of *viduus* (U. S. N. M. no. 30259) has been examined and is typical of the form here defined under that name. There is no evidence in it of a light streak along the vertebral scale row

Conophis pulcher pulcher Cope

Conophis pulcher Cope, Proc. Acad Nat. Sci. Philadelphia, 1868: 308 (Petén, Guatemala; three cotypes, U. S. N. M. nos. 6751, 6803) —Bocourt, Mission Sci. Mex., Rept., livr. 10: pp 645–647, pl. 38, fig. 6 (a good illustration).   1886.

Diagnosis.—Chin and labial borders pigmented; usually eight supralabials; a dark stripe along first scale row, at least posteriorly; lateral dark stripe (i.e., the continuation of the ocular stripe) involving median half of second scale row, all of third and outer half of fourth, over all of body; a secondary dark stripe on paravertebral scale rows (except on extreme anterior part of body), broken anteriorly (spotted), continuous posteriorly and enclosing a light area one and two half scale rows wide; ends of ventrals spotted or slightly pigmented on some part of body

Distribution.—Known only from "Petén"

Specimens examined—Three, from Petén, Guatemala (U. S. N. M. nos. 6751, 6803)

Remarks.—I have seen no intergrades between this and *lineatus.* The rather sharp difference between these two in position of the lateral stripe and the presence in *pulcher* of secondary paravertebral stripes leads me to believe that intergrades do not occur.

In one specimen of *pulcher* the lateral stripes are solid throughout their length; in two others they are light medially, with regular black edges.

The subspecies *plagosus* is very similar, having the same differences from *lineatus* as *pulcher*

Conophis pulcher plagosus subsp. nov.

Conophis pulcher Cope (part), U. S. Nat Mus Bull **32**: 77. 1887 (a specimen mentioned from "Chiapas," collected by Montes de Oca).

Holotype.—U. S. N. M no. 109707, female, from Tonolá, Chiapas, collected by Hobart M. Smith

Diagnosis.—Chin and labial borders pigmented, but dimly; usually eight supralabials (?); a dark stripe along first scale row, at least posteriorly; lateral dark stripe (i.e., the continuation of the stripe through eye) involving median half of second scale row, all of third and outer half of fourth, over all of body; a series of spots on scales of paravertebral rows, beginning at middle of body, extending to base of tail; spots elongate toward posterior end of body, but not forming a continuous line; ventrals completely unspotted; all lines on body somewhat spotted in appearance.

Scutellation of type.—Ventrals 169; caudals 67; scale rows 19–19–17; supralabials 7–8, infralabials 9; one preocular; two postoculars, two temporals.

Remarks.—This form is differentiated from *pulcher pulcher* by having (1) the ventrals completely unspotted; (2) secondary lines on paravertebral rows not continuous posteriorly; (3) all other lines on body also somewhat

spotted in appearance; (4) dusky markings on chin and supralabial border very dim (less distinct than in *p. pulcher* or any member of the *lineatus* series). Very probably this does not now intergrade with *p. pulcher*, from which it is pretty well isolated. However, its essential characters definitely link it with *p. pulcher*, and the differences between it and the latter are no greater than those between *vittatus* and *viduus*, or between *concolor* and *similis* or *lineatus*.

Conophis lineatus lineatus (Duméril and Bibron)

Tomodon lineatus Duméril and Bibron, Erp. Gen 7: 936–938, pl 73 1854 (Mexico) —Bocourt, Mission Sci Mex., Rept , livr 10: 643, pl 38, fig 5 (an excellent illustration of one of the types). 1886

Diagnosis.—Chin and labial borders pigmented; usually eight supralabials; a dark stripe along first scale row, at least posteriorly, lateral dark stripe (i e , the continuations of the stripe through eye) very narrow posterior to nape, extending along fourth scale row; posteriorly a stripe along third and eighth (farther posteriorly the seventh) scale rows; a narrow dark stripe along sixth scale row, continuous throughout length of body, another narrow dark stripe, more spotted anteriorly, on first scale row; all stripes at least slightly spotted in appearance; ends of ventrals spotted in at least some part of body

Distribution.—The only specimen known with definite locality is from Paso del Macho, Veracruz

Specimen examined —One, from Paso del Macho, Veracruz (U. S N. M no. 109708).

Remarks —The character of the lateral stripes easily distinguishes this from *l. similis;* a second prominent difference is the presence of a secondary line posteriorly along the seventh scale row

The identity of the types of *lineatus* is none too well fixed, in spite of Bocourt's excellent illustration of one of them I have concluded that the name is based upon the Mexican form rather than the Costa Rican, for the following reasons: (1) Types said to be from Mexico; (2) no markings on third scale row shown on types (dorsolateral stripes involve most of third scale row in *similis*, the condition in the types, even to the small spots on the scales of the second row, is matched by the Mexican specimen available at least on one part of body); (3) markings on eighth scale row (beginning of secondary stripe) shown for types, as in the Mexican specimen (*similis* shows no such markings)

Conophis lineatus concolor Cope

Conophis concolor Cope, Proc Acad. Nat. Sci Philadelphia, 1866: 318 (Yucatán; two cotypes, U. S. N. M. no. 12368)

Diagnosis.—Chin and labial border pigmented; usually eight supralabials; no stripes evident on body, dorsal surface gray, ventral surface white, the dorsal color extending onto first scale row; three stripes on head, the median poorly defined, all disappearing on neck.

Distribution —Peninsula of Yucatán and area at its base, east through northern Honduras

Specimens examined.—Five, including the cotypes and U. S. N. M. no. 4941, Petén (?), Guatemala; U. S. N. M. no. 20271, Patuca Honduras; and U. S. N. M. no. 46395, Chichen Itza, Yucatán.

Remarks.—Several specimens, all typical, are known from the Peninsula of Yucatán. In addition, a perfectly typical example from Patuca, Honduras, is present in the National Museum (no. 20271).

An intergrade between *concolor* and probably *lineatus* is in the National Museum (no 4941) The catalog states that this is from El Salvador, collected by J. M. Dow. However, an old paper label, on which is written *"Conophis vittatus*, Petén, J. M. Dow," is in the bottle, and accordingly I think this is the specimen, from that locality, mentioned by Cope in 1887 (U. S. Nat. Mus. Bull. **32**: 76) under the name *vittatus* It is certain, moreover, that this specimen is an example of what Cope believed *vittatus* to be, for he states in 1876 (Journ Acad Nat. Sci Philadelphia (2), **8**: 137) that this species has the "body without bands, but faint traces of them on first, third and seventh rows of scales." This certainly applies to the specimen in question

In this intergrade the median dark stripe on the head is well defined, as are the lateral head stripes; these disappear on the nape. A dark stripe extends the full length of the body on the first scale row; anteriorly and in the middle of the body it is dim, poorly defined. A fine, dotted black line, beginning a little anterior to the middle of the body, extends along the fourth scale row to the position of scale row drop; from this point to the anus it is continued on the third scale row; in the extreme posterior part of body a similar line extends along the fourth scale row to anus At about the middle of the body a fine, dotted dark line becomes evident on the seventh scale row; it becomes more distinct posteriorly, becoming almost continuous near base of tail; posterior to the position of scale row drop it follows the sixth scale row.

Conophis lineatus similis subsp. nov.

Conophis lineatus Cope (*nec* Duméril and Bibron), U S Nat Mus Bull **32**: 77. 1887 (San José, Costa Rica; Nicaragua).

Holotype —U. S. N. M. no. 79963, female, Managua, Nicaragua, collected by Lt. H. C. Kellers.

Paratypes.—Three, one a topotype (U S. N. M no. 79964); one, in very poor condition, from "Nicaragua" (U S N M no 25237); and one from Esparta, Costa Rica (U S N. M. no. 37758).

Diagnosis.—Chin and labial borders heavily pigmented; usually eight supralabials; a dark stripe along first scale row; lateral dark stripe (i.e , that which passes through eye) restricted to the third and fourth scale rows throughout the length of the body, solid (without a broad light median area between two dark edges); a dark stripe on seventh (sixth posteriorly) scale row; no secondary dark stripes on either paravertebral rows or those adjacent to them laterally; second scale row white anteriorly, posteriorly with a dotted secondary line; ends of ventrals pigmented in some part of body.

Scutellation of holotype —Ventrals 170; anal divided; caudals 69; scale

rows 19–19–17; supralabials 8–8; infralabials 10–11; one preocular; two post-oculars; temporals 2+2. Total length 553 mm; tail 121 mm.

Variations.—The ventrals and caudals, respectively, of the paratypes, in the order listed above, are: 169, 67 (♀); 174, 69 (♀) 170, 64(♂). Scale rows 19–19–17 in all; supralabials 7–8 in one, 8–8 in others; infralabials 8–9 in one, 9–9 in one, 10–11 in one; oculars and temporals as in type.

The topotypic paratype has the same pattern as the type The stripes on the seventh scale rows are composed of small spots; all the stripes on the body give a spotted effect, although all except those on the seventh scale rows are continuous at least posteriorly The chin and labial markings are very prominent, as are the spots on the ends of the ventrals

The paratype from "Nicaragua" is very similar in coloration, except that the stripes on the seventh scale rows are continuous.

The paratype from Esparta, Costa Rica, does not show such a strong spotted effect as the'others, the stripes on the seventh scale rows are broader, and the area between these two stripes is generally suffused with darker.

PROCEEDINGS OF THE ACADEMY
AND AFFILIATED SOCIETIES

THE ACADEMY

365TH MEETING OF THE BOARD OF MANAGERS

The 365th meeting of the Board of Managers was held in the Board Room of the Cosmos Club on Friday, January 10, 1941 President CRITTENDEN called the meeting to order at 8:02 P M , with 16 persons present, as follows: E C. CRITTENDEN, F D ROSSINI, H S RAPPLEYE, G STEINER, A. T McPHERSON, A. H CLARK, W A DAYTON, H L CURTIS, W. RAMBERG, E. W. PRICE, C L GAZIN, W. W. DIEHL, and by invitation J H KEMPTON, R J SEEGER, and O H GISH

The minutes of the 364th meeting were read and approved

President CRITTENDEN announced the appointment of the most recent past Corresponding Secretary, N R SMITH, to the position of Archivist of the Academy for a term of 3 years.

C L. GARNER, chairman of the Committee on Meetings, reported that negotiations were under way to have WARREN KELCHNER, chief of the Division of International Conferences of the U. S. Department of State, address the Academy at its meeting in April, with the other meetings as previously reported Chairman GARNER also reported that his Committee had an unexpended balance of $29.20 from its budget allotment for 1940.

G STEINER, chairman of the Committee on Membership, presented nominations for membership for 8 persons (5 resident and 3 nonresident).

The Board considered individually and duly elected to membership the 11 persons (9 resident and 2 nonresident) whose nominations were presented to the Board on December 6, 1940.

The Committee to Consider the Printing Contract for the Journal, F. G BRICKWEDDE, chairman, presented its final report, recommending that the present contract be continued. In an appendix to its report, the Chairman presented some information concerning the possibility of saving several hundred dollars a year in the cost of publishing the Journal through the adoption of a 2-column format and 2 point smaller type, at the same time maintaining the present standards of quality and workmanship and the same average number of words to the issue It was moved and carried that the Committee's

report be accepted, and further that "the Board of Editors shall consider the desirability of changing the Journal to a 2-column format and report its recommendations within 3 months."

The Committees on Awards for Scientific Achievement for 1940 presented the following recommendations with regard to these awards, which are limited to persons 40 years of age or less: For the Biological Sciences, A H CLARK, chairman, reported that his Committee found no eligible candidate within the prescribed age limit who was considered worthy of the award, and therefore recommended that no award for 1940 be made for the biological sciences For the Engineering Sciences, the Committee, F. M. DEFANDORF, chairman, recommended that the award for 1940 be made to HARRY DIAMOND, principal physicist in the Radio Section of the National Bureau of Standards, for his work in the development of methods and apparatus for the "blind-landing" of aircraft, in the development of methods and apparatus for obtaining meteorological data from appropriately equipped balloons sent into the atmosphere, and in the development of an automatic weather-reporting station For the Physical Sciences, O H GISH, chairman, reported that his Committee recommended that the award for 1940 be made to FERDINAND G. BRICKWEDDE, chief of the Cryogenic Laboratory at the National Bureau of Standards, for his work in assisting in the discovery of deuterium, in determining the physical properties of the various isotopic forms of the hydrogen molecule, and in establishing a working temperature scale for the range 14° to 83° Kelvin. It was moved and carried that the Board make the awards as recommended by the Committees

The Committee to Consider Several Problems Relating to the Journal, W. W DIEHL, chairman, presented a report recommending that (1) the number of copies of the Journal to be printed currently each month shall always exceed the membership and subscription list by a margin of at least 75, (2) for the purpose of ensuring future sales, particularly as a service to new subscribers, there be authorized a reserve of 25 sets, from which no numbers or volumes may be sold except in complete sets, consisting of 8 sets of volumes 1 to 30, 6 sets of volumes 11 to 30, and 11 sets of volumes 16 to 30, and that a reserve of 25 complete volumes shall be provided each year thereafter; and (3) the first $300 realized from the sale of complete sets of the Journal shall be retained in the Treasury at the disposal of the Custodian and Subscription Manager of Publications, to be used at his discretion for the sole purpose of completing the contemplated 25 reserve sets now only partially complete The Board accepted and approved these recommendations

The Corresponding Secretary presented the following statistics regarding the membership: Deaths, 1; acceptance to membership, 1; members qualifying by payment of initial dues to the Treasurer, 5; retirements, 3; resignations, 4

Adjournment was at 10:20 P.M , at which time the Board partook of refreshments provided by President CRITTENDEN, on the occasion of this last meeting of the Board during his term of office.

FREDERICK D ROSSINI, *Corresponding Secretary*

CHEMICAL SOCIETY

524TH MEETING

The 524th meeting was held in the Hall of Government, George Washington University, on Thursday, October 10, 1940, President HANN presiding. Following the completion of routine business of the Society, the following communications were presented in three sections:

Organic and Biological Chemistry, S N. WRENN presiding

A KOSSIAKOFF and H. SPRINGALL, Catholic University of America: *A structural investigation of the Mills-Nixon effect.*

L. L. MADSEN and R. E. DAVIS, U S Bureau of Animal Industry: *Carotene and vitamin A in cattle blood plasma.*

H. S. ISBELL and H L. FRUSH, National Bureau of Standards: *Reactions and properties of the carbohydrates in relation to the Walden inversion.*

Physical Chemistry, M H VAN HORN presiding

N BEKKEDAHL and L A WOOD, National Bureau of Standards: *Stark rubber.*

G R GREENBANK, U S Bureau of Dairy Industry: *Photochemical oxidation of fats and oils*

E. J JONES (introduced by S B HENDRICKS), U. S Bureau of Plant Industry: *The association of phenol in carbon tetrachloride from infrared data.*

Inorganic and Analytical Chemistry, D C KNOWLES presiding

R. T. O'CONNOR, U S Bureau of Plant Industry: *Spectrochemical methods for the quantitative analysis of trace elements in phosphate rock.*

R R. WHETSTONE, W O ROBINSON, and H G BYERS, U S Bureau of Plant Industry. *The distribution of boron in soils.*

G W. WARD, Portland Cement Association Fellowship at the National Bureau of Standards: *The polarizing microscope: A tool for the simplification of control and standardization of crystalline compounds.*

525TH MEETING

The 525th meeting was held in the Ladies' Parlor of the Cosmos Club on Thursday, October 24, 1940, President HANN presiding. Following the routine business, the Society was addressed by W H SEBRELL, M D , of the National Institute of Health, on *Recent developments in vitamin research.*

526TH MEETING

The 526th meeting was held in the Auditorium of the Cosmos Club on Thursday, November 14, 1940, President HANN presiding Election of officers for the Society for 1941 took place by means of preferential ballot. The following officers were elected·

President		H L. J. HALLER	
Secretary		NORMAN BEKKEDAHL	
Treasurer		E. R SMITH	
Councilors	W D COLLINS	J H HIBBEN	
	R E GIBSON	G E F LUNDELL	
	R M HANN	B H NICOLET	
	M M HARING		
Managers	J J FAHEY	A T McPHERSON	
	S B HENDRICKS	H P WARD	
	H S ISBELL	C E WHITE	

Following the completion of routine business, the Society was addressed by PER K. FROLICH, director of the Chemical Division of the Esso Laboratories, Standard Oil Development Co , Linden, N. J., who spoke on the subject *Frontiers in petroleum chemistry*

527TH MEETING

The 527th meeting of the Society was held in the Auditorium of the Chemistry Building of the Catholic University of America, on Thursday, December 12, 1940, President HANN presiding. After the completion of routine business, the Society was addressed by DAVID HARKER, of the Johns Hopkins University, who spoke on the subject, *Water as a reagent in inorganic chemistry.*

NORMAN BEKKEDAHL, *Secretary*

Obituaries

RAYMOND PEARL, biologist, teacher, editor, and student of human populations and longevity, died suddenly on November 17, 1940, at Hershey, Pa Born on June 3, 1879, at Farmington, N. H , the son of Frank and Ida May (McDuffie) Pearl, he received advanced education at Dartmouth (A B , 1899), the University of Michigan (Ph D , 1902), the University of Leipzig (1905), and the University College of London (1905–06)

After serving for brief periods as instructor in zoology at the University of Michigan (1902–06) and the University of Pennsylvania (1906–07), he was appointed in 1907 as head of the department of biology at the Maine Agricultural Experiment Station From here he went to Baltimore in 1918 as professor of biometry and vital statistics—later (1930) professor of biology—at the School of Hygiene and Public Health, Johns Hopkins University

The basic quality of Dr. Pearl's research has been recognized by the academic honors he received (Sc D , Dartmouth, 1919; LL.D , University of Maine, 1919; Litt D., St John's College, 1935) and by the number of scientific societies to which he belonged, notably the National Academy of Sciences and the American Philosophical Society. Also, he was in frequent demand as a lecturer.

Dr Pearl's publications include the following books: *Diseases of poultry,* 1915; *The biology of death,* 1922; *Introduction to medical biometry and statistics,* 1923; *Studies in human biology,* 1924; *Alcohol and longevity,* 1636; *Constitution and health,* 1933, *The natural history of population,* 1939 He was founder and editor of the journals Quarterly Review of Biology (1926) and Human Biology (1929).

"The world of science has lost a great leader, a fruitful scholar with wide experience and rare originality and a colleague always helpful and stimulating "

WALTER JORGENSEN YOUNG was born at Owensboro, Ky , on June 27, 1883, and died on November 23, 1940, at Fredericksburg, Va Valedictorian of his class in Richmond College, he received his D.D and Th.M at Crozier Theological Seminary and his M S and Ph.D. at the University of Pennsylvania. He was, successively, professor of psychology and biology of Hampden-Sydney College (1911–1913), professor of philosophy and head of the department of philosophy at the University of Richmond (1913–1918), professor of social science at the State Teachers' College at Fredericksburg

(1919–1926) and at the same time minister at the Massaponax Baptist Church and Supervisor of Schools, professor of geography at the University of Tennessee (summer, 1925), professor of education at Winthrop College (1926–1929), and finally, until his death, head of the department of psychology and philosophy at Mary Washington College at Fredericksburg. He published a *Syllabus of comparative ethics* (1918), *Outline of general geography* (1925), and *Outline of early European history* (1925). His original genealogical research, *The Bristol Youngs in America* (1937), won him a Fellowship in the Royal Academy of Arts in London

He obtained the Crozier Research Fellowship for his investigation of experimental psychology, *A study in practice and habit* (1912), introducing new unit methods of procedure in elementary school teaching. By his treatises *The correlation theory of psychology* (1929) and *Cause and effect* (1929), he tried to combine the new ideas introduced by Einstein and his successors with the Gestalt hypothesis of the German philosophers and to build a new foundation for the methods of psychology and a new psychological terminology. By these original and thoughtful publications he was brought into international notice

Dr. Young was not a specialist, although his work, done in so various and distant fields of science, always had scientific value and was based on scientific methods. He loved God's colored world and was too much interested in understanding the whole to confine himself to some little corner. So he did not become a truly great specialist, but he was a truly great teacher, understanding the whole of life and interested in all spheres of science.

Dr. Young married Ethel Daniel and had two children: a daughter, Patricia Ann, the wife of Dr James King in Fredericksburg; and a son, Walter J , Jr , chemist at the Sylvania Plant in the same city. Among his pupils and colleagues the memory of his splendid and lively personality will be fresh for a long time.

ECOLOGY.—*Adaptive coloration in a single faunal association.*[1] Theodore H. Eaton, Jr., Cornell University. (Communicated by C. Lewis Gazin.)

The meaning and methods of adaptive coloration are stated so fully in Cott's recent book (1940) that a general survey of the subject may not be needed again for some years. Rather his work, with its large bibliography, should stimulate special studies and detailed applications of principles. One such problem that has not yet received adequate treatment is the effect of adaptive coloration on the total population of a single ecological association.

An association particularly favorable to such study is the rain forest of Barro Colorado Island in the Canal Zone, now receiving maintenance as a biological reservation from the United States Government. The writer collected there in the summer of 1939.

Barro Colorado Island, in Gatun Lake, is about 6 square miles in area, almost entirely covered by climax rain forest. Over 700 species of trees occur there, the dominant crowns of a few, such as *Bombacopsis felderi*, exceeding 200 feet in height. Most species are broad-leaved hardwoods. A litter of fallen leaves covers the ground nearly everywhere, averaging 1 to 4 inches in depth, but decomposition of this litter is so rapid that the red lateritic clay soil begins directly under it with scarcely any or humus layer. The undergrowth varies in density but in most places is not thick enough to interfere with walking. Although there is little standing water on the island, numerous small streams run down to the lake, their beds being generally of blackened pebbles and boulders.

Thus the niches available for the rain-forest fauna (apart from burrowing, subterranean or aquatic forms) are the following:

1. Trees: Foliage, limbs, trunks, crevices.
2. Epiphytic vegetation, including llanas, bromeliads, ferns, mosses, etc.
3. Undergrowth: Foliage, stems.
4. Ground surface, on or under leaf litter.
5. Ravines, stream beds, banks, bare trails, beaches (a relatively small area).

[1] Received February 15, 1941.

ECOLOGICAL RELATIONSHIPS OF THE TYPES
OF COLOR ADAPTATION

I. Color adaptations among rain-forest animals are numerous and varied. Cott (1940) groups them as concealment, advertisement, and disguise. There is a strong correlation between adaptive appearance and the diurnal-nocturnal rhythm. Species that are quiet by day and active by night almost invariably show either concealment or disguise in some form, provided they spend the day in a place exposed to the view of animals that hunt by sight. Many species that are active by day, but that spend a part of that time at rest in such places, show the same thing when they are at rest. Species that mimic others exhibit this feature by day, although in some cases they are nocturnal as well. Warning, display, allure, or directive markings function by day, the species very frequently being active both day and night. Adaptive coloration apparently does not occur among animals that burrow or hide out of the ordinary field of vision. It is lacking, for instance, in certain moths (Pyralidae, Geometridae) and butterflies (Hesperiidae, Erycinidae) that alight regularly on the under sides of leaves, showing themselves only while in rapid flight. Thus adaptive coloration is limited to the species that might be visible by day, and, if seen, accessible, whether as prey or as predators.

II. Relationship between adaptive coloration and niches in the rain-forest association:

A. *Obliterative* or *procryptic* coloration occurs in species that rest or pause against a relatively homogeneous background, that is, one in which separate objects mean little or do not show. This must be interpreted in each case from the standpoint of a casual observer. The animal comes within the field of vision but is so colored that it is not noticed as an object. Backgrounds available for obliteratively colored species on Barro Colorado are these:

(1) Surfaces of green leaves. For obliterative effect any surface must be larger than the animals on it, i.e., sufficient to serve as a background. The eggs, larvae, and chrysalids of many Lepidoptera, the adults of some (Geometridae especially), many Coleoptera, Hemiptera, Homoptera, and Orthoptera, some spiders and some tree frogs are cryptically colored on green leaves.

(2) Foliage en masse. Certain larger animals show an obliterative green against the background of massed foliage, which from a distance can be regarded as homogeneous. Such are the green tree-snakes, lizards like *Polychrus gutturosus* and *Iguana iguana*, and many, if not all, of the green birds.

(3) Tree trunks, root buttresses, fallen logs. Procryptic animals here include Lepidoptera (Noctuidae, Notodontidae, Geometridae, Sphingidae, some nymphalid and brassolid butterflies), many caterpillars, Coleoptera such as cerambycids, elaterids, and some prionids, certain spiders, tree frogs, and geckos.

(4) Leaf litter, probably 99 per cent of the ground cover in the forest. Animals deceptively colored like this background include Lepidoptera (Noctuidae, Notodontidae, Geometridae, Satyridae, Nymphalidae, and others), some Orthoptera and spiders, many frogs, toads, lizards, and snakes, ground birds such as tinamous and (by day) nighthawks. Many of the Lepidoptera show a partial leaf-vein pattern on their wings, but the shape of the wings is usually not leaflike, since obliteration rather than object-imitation is the result achieved. Satyrid butterflies of the genus *Pierella* are common examples of this. While the leaf litter is relatively homogeneous as a background, enough contrast of light, shade, and sharp edges occurs to cause disruptive patterns frequently to accompany obliterative coloring in the species that occupy this niche.

(5) Bare ground, as mud beside streams, open trails, banks, etc. A dark purple-brown *Cicindela* is common and procryptically colored on the trails, so that only careful watching will detect it before it flies. The tendency of many species of tiger beetles to show the color of their background is familiar. Dice and Blossom (1937) recently pointed out that the same is true of local races of *Peromyscus* living in open, arid country, but is less likely to occur in covered areas.

B. *Disruptive pattern* is common in connection with obliterative background resemblance. Its effect is to add a seeming discontinuity to the procryptic effect already achieved. An excellent example, one among many in Lepidoptera, is the large, brown satyrid *Antirrhaea miltiades*, in which a white blotch and streak on the hind wings destroy any probable recognition of the butterfly as a separate object when it alights on dead leaves. The remainder of the pattern is dead-leaf brown. Most cases of deceptive rupture of pattern will probably be found to work when the rest of the pattern is obliterative and the background moderately heterogeneous. Accordingly the leaf-litter fauna should be, and is, particularly rich in this kind of adaptive coloration. Species on pebbly ground and on rough tree trunks often show it as well.

C. *Object resemblance.* Cott uses the term "disguise" to cover this and the usual mimicry between species. "Object resemblance" expresses somewhat more exactly the meaning of the present category.

This type of deception is found in niches occupied largely by discrete objects, such as leaves, twigs, or thorns. Species that resemble these objects do so by adaptation not only of color but of form. The disguise is most effective while the animal is motionless, except when the objects in question happen to move, in which case the animal may do so. Many of the amazingly twiglike Phasmidae (Orthoptera) sway rhythmically from side to side like twigs in a breeze. Certain Mantidae have also become twiglike. *Dinopis*, a spider, fits its legs together in line with the body and hangs motionless like a piece of dead twig on an inconspicuous thread. Among the twig-imitators should also go the spider that prepares a line of frass with a half-inch gap, into which it then fits and so completes the artificial twig. Twiglike geometrid larvae are common, as are the thornlike membracids. It is a rule that these types occur in places where the particular thorns or twigs they resemble also prevail.

Examples of leaf-imitation involving the color, pattern, and form of leaves are: Leaf-mantids (some resembling living, others dead leaves), leaf-butterflies, and a few large moths, like *Ophideres*, which hangs in a most convincing manner like a dead leaf from the stem of a low bush.

D. *Transparency.* It is, of course, impossible for a flying insect to achieve complete transparency, although many aquatic organisms, including prawns in Gatun Lake, have nearly or quite done so. Yet a filmy translucence affecting the larger part of the insect has a highly deceptive function. Sometimes it is combined with a contrasting pattern, as in some of the largest forest damselflies (Zygoptera, Coenagrionidae), where at the tip of each wing is a yellow, white, or blue spot, and the insect as a whole is difficult to see in flight because almost nothing shows but these separated, vibrating spots. Transparency has developed among butterflies in more than one shade-living group independently, the most important being Ithomiidae. *Ithomia, Leucothyris,* and some other genera are partly transparent and deceptive while flying in the gloom of the forest. They do not occur in strong light. *Cithaerias menander* is a transparent satyrid, also occurring in deep shade. Across its wings are faint vestiges of the leaf-vein lines that are present in some allied brown satyrids with an obliterative dead-leaf pattern. This suggests that *Cithaerias* has changed a former obliterative appearance for transparency, equally deceptive and functioning in flight as well as at rest.

E. *Mimicry* between unrelated species is a type of deception that *reduces the total number of apparent species* in a given ecological as-

sociation. This is accomplished by duplication of color, pattern, form, and behavior, at least outwardly. A mimetic group of unrelated species, consisting of two to six or more species, thus appears to be one by sharing a particular configuration.

The term "configuration" is used here to imply a connection with the Gestalt theory of learning. Each mimetic group, appearing to be a species, is a configuration or "Gestalt" to the predator, and a response of avoidance or acceptance is learned on the basis of experimental or haphazard encounters between the predator and its prey. A reduction of the number of Gestalten to be recognized can only simplify the learning process, by reducing the number of encounters needed to fix a given Gestalt in the predator's memory. Mimicry accomplishes this reduction. The learned response to a mimetic group appears in every case to be avoidance, since this kind of Gestalt happens to provide a disagreeable experience in a large proportion of possible encounters.

Mimicry observed in Panama shows, as a whole, no definite correlation with ecological niches, except that, like other adaptive coloration, it functions by day within the field of vision of species that hunt by sight. Mimetic groups seen were the following:

(1) Mutillid wasp, female, mimicked by cicindelid beetle.

(2) Winged wasps (probably a complex including models for several different mimetic groups), mimicked by certain Diptera, staphylinid beetles, euchromiid moths.

(3) Bees, mimicked by numerous Diptera.

(4) Ants, mimicked by spiders (especially attids), by cerambycid beetles, and by a mantid. Here again more than one mimetic group occurs, for the ants mimicked by the mantid are poncrids, while those mimicked by the spiders and beetles are various formicids.

(5) Lycid beetles, mimicked by euchromiid moths (*Dycladia, Correbia, Correbidia*) and by arctiids (*Lycomorphodes*, Forbes, 1939). Many other insects have been reported as lycid mimics in Asia and Africa (Carpenter, 1920).

(6) A lampyrid beetle, mimicked by an arctiid moth, *Diarhabdosia*.

(7) Danaid butterflies, mimicked by ithomiids, papilionids, and female pericopid moths.

(8) Heliconid butterflies, mimicked by ithomiids and pierids.

(9) *Papilio* (some of the *Aristolochia*-feeding species), mimicked by certain pericopid moths (Forbes, 1939).

F. *Directive* (misleading) markings and behavior. In this category I include the cases in which a part of the animal looks and acts like something it is not, while the remainder is free from any deceptive

effect, and may, indeed, be highly conspicuous. This comes under "advertisement" in Cott's (1940) work. Many of the hair-streak butterflies (Theclinae) have on the under side of the wings a showy pattern of lines and stripes, visible when they alight, with wings upright. At the posterior end of the hind wings is a red or orange spot, beyond which one or two hairlike tails project. The butterfly, when at rest, constantly moves the hind wings up and down against each other, imparting a writhing motion to the spot and active wriggling to the tails. Whether this is a "false head" with "false antennae" to lure possible attackers away from the "vital" to some "nonvital" part of the body is a question on which agreement may be difficult; it is a fact that one is temporarily deceived as to the actual head of the insect, and that insectivorous birds and lizards usually respond to moving rather than motionless objects.

G. *Warning* and *display*. Deception is a minor factor in this kind of advertisement, except when the species are already deceptive through mimicry, as with the color-display and fake stinging motions of the wasplike staphylinid beetles. A more typical case of simple "warning" is the bright green and shiny black pattern of the frog *Dendrobates auratus*. This species is common in the forest of Barro Colorado, active by day and night, and a highly conspicuous animal for its size. Its poisonous skin secretion is quickly associated with the striking colors.

CONCLUSIONS

1. The kinds of adaptive coloration occurring in the rain-forest fauna are correlated with particular niches in that association. Obliterative color and pattern occur where the background is relatively homogeneous. Obliterative-ruptive patterns are correlated with a more heterogeneous background, yet one in which separate objects mean little. Object-resemblance is common in an environment composed of discrete details (leaves, twigs, thorns). Transparency occurs in shade-dwelling, large-winged insects. Mimicry reduces the apparent number of species to be recognized. Directive markings, warning, display, and the lack of adaptive coloration show no specific environmental correlation, except that species which burrow or hide out of the ordinary field of vision are unlikely to be adaptively colored in any way.

2. The total population, both of species and of individuals, occupying this faunal association appears to be much greater than would be possible in the absence of adaptive coloration, because (a) species

with obliterative, disruptive, object-imitative, or mimetic adaptations are less frequently noticed, or, if noticed, are avoided; (b) those with misleading markings or deceptive transparency may be noticed but remain relatively inaccessible; (c) those with warning coloration associated with disagreeable traits are usually avoided. To express this in figures would mean little, however, since (a) enormous groups rather than a few species are involved, (b) relatively few species-determinations of rain-forest insects from any one locality are available, and (c) the ratio between adaptively and nonadaptively colored species must be, in the nature of the case, inconstant.

Since the recent literature, very adequately cited by Cott (1940), contains evidence on nocturnal behavior, on color vision in insects and other animals, and on the selective value of various kinds of adaptive coloration, this material is omitted from the present paper, although much that is pertinent might be taken from it.

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CARPENTER, G D H   A naturalist on Lake Victoria   London, 1920
COTT, H B.   Adaptive coloration in animals.   New York, 1940
DICE, L R, and BLOSSOM, P M   Studies of mammalian ecology in southwestern North America with special attention to the colors of desert mammals   Carnegie Inst Washington Publ 485: iv +129 pp , 8 pls , 8 figs   1937
FORBES, W T M   The Lepidoptera of Barro Colorado Island, Panama   Bull Mus. Comp Zool 85(4) 99–322, 8 pls   1939

ZOOLOGY.—*The gender of scientific names in zoology.*[1] RICHARD E. BLACKWELDER, U. S. National Museum.

The scientific names of animals, according to the International Rules of Zoological Nomenclature, must be words that are either Latin or Latinized, or that are considered and treated as such in case they are not of classic origin. Both generic and specific names are to be formed according to the principles of Latin grammar and usually have Latin endings. Specific names must bear the proper modifying relation to the generic name and may have a variable ending for this purpose. For example, adjectives must agree in gender with the generic name, substantives in apposition must be in the nominative case, and possessive substantives must be in the genitive case.

Our Zoological Code specifies these principles and some others but

in general places the responsibility upon the individual to know and follow the Latin grammar.

Most research in taxonomy has been done by persons of some education, and this has very frequently meant in the past a classical one. A thorough knowledge of both Latin and Greek was considered a necessity in any education, and nearly every taxonomist of a generation or more ago had a good working knowledge of both the principles and the vocabularies of these languages. At the present time, however, it is quite possible for a student to reach the highest steps of our formal education system without a knowledge of either of these languages, and in fact few students do in these days receive a really thorough training in either of them. It has become, therefore, increasingly difficult for modern taxonomists as a group to apply uniformly the Latin rules that should govern their actions in the choice and formation of names and the use of the proper endings. And this tendency has had a marked effect on the number of mistakes made by the persons who make use of zoological names.

Perhaps the commonest problem of this sort is the question of what ending to use when a specific name is transferred from one genus to another. For example, *Cylindropsis polita* is transferred to *Osorius* and must be changed to *Osorius politus*, since *polita* is an adjective and must agree in gender with the generic name which is a noun. If the specific name were *rufipennis*, it would not change, since the masculine and the feminine endings are the same in this declension. If the specific name were *ajax*, it would not change, since it is a substantive and these are not required to agree with the generic name in gender. Situations may be much less simple than this, as in the case of *Venus*, which is feminine in spite of its masculine ending, and such combinations as *Tenaspis angulosa* (3d decl. f. noun and 1st decl. adjective), *Tenaspis angularis* (3d decl. f. noun and 3d decl. adjective), *Eros aurora* (3d decl. m. noun and 1st decl. f. noun in appositon), *Erotides hebes* (3d decl. f. noun and 3d decl. f. noun in apposition), *Sphex latus* (3d decl. m. noun and 2d decl. m. adjective), *Microps fungi* (3d decl. f. noun and 2d. decl. m. possessive noun), *Microps minor* (3d decl. f. noun and comparative adjective of 3d decl.).

A person who is not thoroughly familiar with each of the Latin declensions frequently is at a loss to know what change in ending should be made. Fortunately a large part of our names end in the familiar *us, a, um* endings and many more in the *is, is, e*. But even when one recognizes these, what about the *ger, gera, gerum* and *ger, gra, grum* endings, the *as, es, os, ps, rs, or, x*, etc., which never change,

and the *a, e, m, is*, etc., which sometimes change and sometimes do not when the gender of the generic name changes?

Then there are a considerable number of names that defy even the Latin rules by virtue of a gender inherent in their meanings. *Venus* takes feminine specific names and *Adonis* takes masculine, in direct opposition to the usual gender of words ending as these do. Many words ending in *a* derived from the Greek, such as *Conosoma* and *Strigoderma*, retain the neuter gender which they had in that language. There is no way to recognize these words from themselves, one must simply know in advance how they are to be used.

Like many of the younger entomologists I have encountered considerable difficulty in these matters because of my lack of a sufficient knowledge of Latin grammar and vocabulary. I find that there is a strong temptation to abandon these requirements and simply use at all times the exact original form of the specific name regardless of other considerations. I believe that this *will* be the result if we continue to base our procedure on the rules of grammar of a language not well known to all the people involved, but I also believe that this would be an unfortunate occurrence and that it can be prevented by the use of a simpler set of rules.

In the writings of Col. Thos. L. Casey[2] I chanced upon a suggestion which seemed to offer hope of a better solution. Col. Casey argued as follows[3]:

As generic and specific words are more symbols for the designation of a species, it seems desirable that they should be withdrawn as far as possible from exceptions to general rules of grammar, and, that in this respect as least, they should be treated in the abstract as mere aggregations of letters   The rules of gender should be made uniform, so that generic symbols ending in a certain manner shall demand a certain definite and invariable gender in the specific symbol

The only course left, therefore, is to consider the generic name as a simple harmonious combination of letters, having a Latin form, constructed without absolutely essential reference to rigidly correct orthography in the language from which it may have been derived, whether Greek, Latin, or aboriginal American, and subject to constant rules of gender which shall be independent of linguistic caprice   The word may or may not have a meaning in the original language from which it is taken, although in any event, the meaning is of but little material importance

An attempt at uniformity involving a suppression of the rules of orthography, and made in a spirit similar to that which has prompted the above remarks, has recently come into quite general use—I allude to the growing custom of writing all specific names, whether proper or common, with a small initial letter   All such rules as this, which have for their object the attainment of simplicity and uniformity in scientific nomenclature, are undoubtedly very desirable.

[2] One of the most studious and prolific writers on Coleoptera of the past generation.
[3] Ann New York Acad Sci **5**: 307–308. 1890.

Col. Casey proposes that for generic names the endings *as, es, os, us,* *r,* and *o* be established as masculine, that *a, is, s* preceded by a consonant, *ys, e,* and *x* be feminine, and that *m* and *n* be neuter. These would be invariable, the ending itself determining the gender of the name. In using the above rule for several years I have found it very useful but have wished for a more comprehensive list and also for a similar aid in determining what endings to use on the specific name in each case. By compiling lists of names and comparing them with Latin grammars I have been able to assemble a table of endings which does seem to make it possible to determine the proper ending in any case according to set rules and with a minimum of trouble.

Generic names formed by arbitrary combinations of letters may end with any letter, as *Anzac, Coati, Arrup, Biat,* and *Coendou.* These names appear to be valid under Article 3 of the Rules, but their gender is not a matter to be guessed offhand by anyone except the original author. Of the above names *Anzac, Arrup,* and *Coendou* were originally used as masculine, *Coati* and *Biat* were used as feminine. Although in some respects it would seem proper for an author to determine the gender of a name in such cases, it will lead only to confusion, since all subsequent users of the name will be under the necessity of referring to the original article to determine the gender. In order to avoid this and to reduce the matter to a single rule that can be fitted into the above system, the following has been compiled principally from Latin usages. Generic names ending in *b, c, d, f, g, h, j, l, p, q, t,* *v, w,* or *z* or in *i, u,* or *y* shall be considered to be neuter. When we combine this rule with Casey's list, we get Table 1, in which the possible endings of genera are grouped under the appropriate genders. It will enable one to determine the gender of any generic name by it sending.

TABLE 1

Masculine	Feminine	Neuter
er, ir or, os us, ex	a, e, as, es, is, s (preceded by a consonant), x (except ex)	b, c, d, f, g, h, i, j, k, l, m, n, o, p, q; ar, ur, t, u, v, w, y, z

To determine the proper ending for the specific name one must first know whether it is a substantive or an adjective. The endings of substantives can not be changed under any circumstances, but the endings of adjectives generally must be changed if there is a change of gender in the generic name.

Adjectives can end (in the singular[4]) only with the following letters or combinations: *a, e, um, er, is, us.*[5] Names ending in these letters are likely to be adjectives but may occasionally be substantives. If one does not recognize any particular name as an adjective, resort must be had to a dictionary. However, unless such a name can be shown to be a substantive, it is best to treat it as an adjective and change its ending to agree with the generic name. For example, the name *nigrita* has been used at times as a substantive and at other times as an adjective. The derivation of the name is open to question, but much confusion can be avoided by treating it as an adjective.

In Table 2 an attempt has been made to indicate the gender of every possible ending of an adjective specific name (as herein restricted) and to show the proper endings of this name in the other genders as well. The gender of any ending in the first columns is indicated by the gender column in which the italics occur.

<div align="center">TABLE 2</div>

Endings				Gender			Example
Final Letter	Preceded by	(preceded by)	(preceded by)	Masc	Fem	Neut	
a	r			er	(e)ra	(e)rum	rubra
a	(any other)			us	a	um	rugosa
e				is	is	e	acre
m	u	r		er	(e)ra	(e)rum	rubrum
m	u	(any other)		us	a	um	rugosum
r	e	ch		er	ra	rum	pulcher
r	e	n, p, s	a, c,[3] i, o, u	er	era	erum	tener
r	o	(any other)	a,[3] e, o, u	er	ra	rum	sacer
r	o	(any other)	i,[1] consonant[4]	er	era	erum	armiger
s	i			is	is	e	debilis
s	u[5]			us	a	um	rugosus

[1] Except *niger* and its compounds, and *piger*, which are -*iger*, -*igra*, -*igrum*
[2] Except *lacer*, -*era*, -*erum* and *acer, alacer*, -*ris*, -*re*
[3] Except *degener*, -*eris*, -*ere*
[4] Except *volucer*, -*cris*, -*cre*, and the alternative masculines of many words, as *equester, equestris, paluster, palustris*, and *acer, acris*
[5] Except the neuter of comparative adjectives (*majus, minus, latius*, etc.) which are herein treated as substantives

Names with any endings other than *a, e, um, er, is, us,* must be substantives (or adjectives treated as substantives), but as noted

[4] Since the Rules specify that generic names must be in the nominative singular, the modifying adjectives must also be singular.
[5] In Latin a few adjectives with imperfect or unusual declension in the singular may end in such combinations as. *i, am, em, ar, or, as, es, us, os, ps*, and *rs* Except for the comparative adjectives (*or, ar, us*) these generally have the same form in all genders and they are all therefore herein treated as substantives rather than adjectives. Words ending in *x* cannot properly be said to be irregular or imperfect, but, since their endings are the same in all genders, they may be omitted from the table and treated with the substantives

above substantives may end in any letter (especially *a, e, i, m, n, o, r, s, x*). The ending of a substantive does not ever change.

The foregoing statements have been made in part as though they were principles of Latin grammar and in part as though they were suggested departures therefrom. This is exactly the case and it will be well to recapitulate the changes that are proposed. If the names of animals are considered to be symbols for species and genera rather than Latin names for them, we find ourselves at once cut off from any set of rules of orthography. Our International Code specifies that "the scientific names of animals must be words which are either Latin or Latinized, or considered and treated as such in case they are not of classic origin." Our symbols can be included in the latter category. An improvement can be made, however, over the Latin usages of gender. Since our names are symbols and no longer have a meaning of their own, they no longer possess an inherent gender. It has been customary to assign a gender to them depending on the declension to which they would have belonged in Latin, but there were exceptions due to inherent gender in the words themselves, for example *Venus* (feminine) and *Adonis* (masculine). In many cases writers have never been able to agree on the proper gender, one basing his claim on the structure of the word and the other upon its original meaning. All this could be avoided in the future by the adoption of a fixed gender for each possible ending, these being based on Latin grammar but being more comprehensive while admitting no exceptions.

The only change then is a standardization of the few variables that now exist and the addition of a few new factors to cover names which could not have existed in true Latin. The aim is uniformity in the agreement of specific names with generic names, and I believe that the proposals here made can be accepted into our present procedures without any change in the International Rules. Names will still be treated as if they were of classic origin, they will still agree grammatically with the generic name. We need only interpret the word "grammatically" to include a more rigid rule of ending than in the previous use of Latin grammar.

ENTOMOLOGY.—*New American Tingitidae (Hemiptera).*[1]   Carl
   J. Drake, Iowa State College, Ames, Iowa.

This paper contains the descriptions of seven new American lace
bugs, including one from Guam Island. Two of the species were inter-
cepted at ports of entry into the United States by Federal quarantine
officials; *Phatnoma ecuadoris* at New York City and *P. barberi* at
San Francisco from Ecuador. The types of all the new species are in
the U. S. National Museum.

Phatnoma ecuadoris, sp. nov.

Allied to *P. varians* Drake, but readily distinguishable by its wider para-
nota, more elevated carinae, and slenderer form. Head with seven spines, the
middle pair stouter at the base than in *varians*. Antennae rather long, slender,
segment III about three and one-half times as long as IV, the latter mostly
black. Bucculae longer, more widely reticulated, less excavated on each side
before apex and not so strongly produced downward at apex as in *varians*
Rostrum long, testaceous
   Pronotum moderately convex, coarsely pitted, tricarinate; lateral carinae
more elevated, the areolae a little larger; paranota wider and more sharply
angulate at the sides than in *varians*, biseriate behind, triseriate in front and
quadriseriate at lateral angle; collar raised, composed of three rows of areo-
lae. Elytra grayish brown, the enlarged, transverse nervures and some of the
nervelets dark fuscous; costal area moderately broad, quadriseriate in basal
fourth, thence to apex largely triseriate; subcostal are a broader, largely five
areolae deep; discoidal area long, about three-fourths the length of the elytra,
five areolae deep in central portion, the outer boundary raised and its ner-
vure for about three-fourths of its length foliaceous and composed of one row of
low, rectangular areolae, the inner boundary also raised, foliaceous and uni-
seriate for almost its entire length; sutural area brownish, without markings
   Length, 2.90 mm; width, 1 30 mm.
   Holotype, male, Ecuador, collected in bananas at port of entry, New York
City.

Phatnoma barberi, sp. nov.

Head black, with seven long, slender, pale-tipped spines, the front pair and
median a little longer than the middle pair, the hind pair much longer, slen-
derer, and strongly curved forward. Bucculae long, dark brown, contiguous in
front. Rostral laminae pale testaceous, subparallel; rostrum testaceous, very
long, extending on venter Legs moderately long, dark-fuscous, the tibiae
and tarsi largely brown. Eyes black. Antennae dark fuscous, moderately
long; segment I much stouter and twice as long as II; III long, a little more
than twice as long as IV, becoming darker apically; IV darker, rather long,
moderately swollen on the distal half.
   Pronotum very coarsely pitted, moderately convex, dark ferruginous,
shiny, tricarinate; median carina uniseriate, the areolae rather small; lateral
carinae parallel, not quite extending to calli, each uniseriate, but not quite so
high as median; collar distinctly raised, areolate; paranota similar in form to
P. marmorata Champ., but not quite so wide, mostly three to four areolae

deep, the areolae hyaline, the hind margin pale. Scutellum exposed, small. Elytra strongly overlapping and rounded posteriorly, brown, with whitish testaceous markings and some of the transverse nervures of costal area dark fuscous; costal area broad, four areolae deep on basal and apical portions, three deep in middle, the areolae hyaline; subcostal area broad, finely reticulated, largely five areolae deep, with four, enlarged, whitish, transverse nervures; discoidal area broad, long, extending to the apical fourth of elytra, with three enlarged, whitish, transverse nervures, the nervure separating it from subcostal area raised, foliaceous, with one row of moderately large areolae, the apical margin not raised or reticulate, the inner boundary raised, uniseriate, not quite so high as outer nervure and extending posteriorly between subcostal and discoidal area. Wings slightly longer than abdomen.

Length, 2.95 mm, width, 1.25 mm.

Holotype, female, Colombia, South America, intercepted by Federal inspectors at Port of Entry, San Francisco, Calif.

This species is very distinct and not easily confused with any other member of the genus. It is about the size of *P. varians* Drake from French Guiana, but readily separated from it by the foliaceous carinae and foliaceous nervures bounding discoidal area. *P. marmorata* Champ. has a much broader costal area and is differently colored.

Tingis guamensis, sp. nov

Moderately large, without hairs, testaceous, with inconspicuous brown markings. Head flat above, testaceous, without spines. Eyes very large, dark reddish brown. Rostrum extending almost to end of sulcus, brownish, black at apex; laminae foliaceous, pale, testaceous, becoming more widely separated posteriorly, concave within on each side on both mesosternum and prosternum, connected at apex by a low narrow ridge. Bucculae broad, testaceous, areolate, closed in front. Antennae moderately long, slender, testaceous, the apical segment brownish, segment I short, stouter and a little longer than II; III a little more than two and a half times as long as IV.

Pronotum very coarsely pitted, convex above, subtruncate, tricarinate, lateral carinae indistinct on disk, obsolete in front, fairly distinct on triangular process; median carina sharply developed and indistinctly areolate; paranota very narrow, linear, slightly broader opposite humeri, there with distinct areolae. Elytra with outer margin rounded and narrowed posteriorly, strongly overlapping and jointly rounded behind; costal area rather broad, with a transverse, fuscous band (veinlets of 6–8 areolae) near middle, mostly biseriate, triseriate in widest part, the areolae rather small; subcostal area broader, six areolae deep in widest part, the areolae small; discoidal area large, reaching a little beyond middle of elytra, eight areolae deep at widest part near middle, narrow at base and apex, the boundary nervures distinct but not prominent, nearly triangular in outline; sutural area more widely areolate posteriorly. Some veinlets of subcostal, discoidal, and sutural areas brownish to dark fuscous.

Length 3 30 mm; width, 1.50 mm.

Holotype, female, Island Guam, D. T. Fulloway.

This species belongs to the subgenus *Tingis* Fabr. and is not easily confused with its congeners

Acalypta mera, sp. nov.

Small, elongate-ovate, grayish brown. Head black, with two short, blunt,

porrect, frontal spines Bucculae open in front. Rostral laminae subparallel, testaceous, not meeting behind; rostrum brownish, black at apex, extending almost to hind margin of first venter. Legs dark brown, the tibiae testaceous, the tips of tarsi black Antennae moderately long, indistinctly pilose; segment I dark brown, much stouter and nearly twice as long as II, the latter dark brown; III testaceous two and one-half times as long as IV; IV almost entirely black, shiny, fusiform.

Pronotum almost flat, very coarsely pitted, almost reticulate in appearance, distinctly areolate behind; carinae foliaceous, each uniseriate, the median slightly more elevated, the lateral carinae strongly divaricating posteriorly, extending from base of hood to hind margin of triangular process. Paranota moderately broad, with moderately large areolae, biseriate in front, uniseriate behind, the outer margins slightly rounded Elytra with costal area uniseriate, the areolae rather large, subcostal area much wider, with four rows of confused areolae; discoidal area large, broad, about three-fourths of the length of the elytra, bounded by a costate nervure, widest for some distance at the middle, there five areolae deep, the outer margin distinctly raised and sinuate.

Length, 1 80 mm; width, 0.50 mm

Holotype, brachypterous male, British Columbia, Canada, September 10, 1928

Of the western species, A. mera is probably most closely related to A. vandykei Drake but is slenderer and has strongly divaricating lateral carinae It may be also separated from A. barberi Drake of New York by its much smaller size, longer rostrum and paranota In the writer's collection, a long-winged specimen of Acalypta from Oregon seems to be A mera

Leptopharsa papella, sp. nov.

Moderately long, broad, testaceous, with brown to dark fuscous markings. Head black, convex above, with five, moderately long, testaceous spines, the median stouter and porrect. Rostrum brownish, dark at apex, extending to middle of mesosternum; rostral channel with sides parallel on mesosternum, broader and cordate on metasternum, open behind. Body beneath brownish black. Legs slender, testaceous, the tarsi dark. Antennae slender, moderately long; segments I and II brown, the former very much stouter and a little more than three times as long; III very slender, testaceous, nearly four times as long as IV, the latter slightly enlarged and brownish black.

Pronotum convex, coarsely pitted, tricarinate, the triangular projection testaceous and reticulate, carinae foliaceous, testaceous, each uniseriate; lateral carinae strongly constricted near the middle, terminating anteriorly a little distance behind the hood; hood moderately large, inflated, slightly produced forward in front, extending backward on pronotum, the crest narrow and part of hind portion; paranota testaceous, moderately large, widest opposite humeri, there broadly angulate and three areolae deep. Elytra broad, strongly overlapping, testaceous; four or five transverse nervures of costal, two small spots in discoidal and apical veinlets of sutural areas embrowned; costal area broad, mostly biseriate, triseriate in widest part; subcostal area broader, mostly triseriate; discoidal area large, extending slightly beyond middle of elytra, there five areolae deep, rounded at apex; sutural area closely reticulated at base, more widely reticulated apically, some of the veinlets along the inner margin and in apical fourth infuscate. Areolae hyaline, iridescent.

Length, 3.30 mm; width, 1.60 mm.

Holotype, female, Ashton, Md , August 27, 1938 P. W. Oman

This species resembles certain members of the genus *Gargaphia* Stal, in general appearance, but does not have an interrupted rostral channel. It differs from *L. velifer* (McAtee) in having a narrower paranota and costal area, smaller hood; the median carina is much less foliaceous and its dorsal margin not so sinuate

Gargaphia valerioi, sp. nov.

Large, whitish testaceous, the pronotum black, the oblique, costate nervures of costal area black-fuscous, the margins of paranota clothed with long pale hair. Head brown, with five slender spines, the median much longer and porrect. Antennae long, beset with long, pale, bristly hairs, brown, the apical segment black; segments I and II dark brown, the former larger and two and one-half times as long as the latter: III about three and three-fourths times the length of IV, the latter long and slightly enlarged. Rostrum extending to transverse suture.

Pronotom black, convex, covered with whitish exudation, the triangular portion reticulate, whitish testaceous, tricarinate; carinae foliaceous, each uniseriate, the areolae large, the lateral carinae on disk faintly convex within, the median distinctly arched on disk of pronotum, hood rather small, narrow to crest, almost conical in form, slightly produced forward at base; paranota broad, strongly reflexed, obtusely produced, widest opposite humeri, there four areolae deep. Elytra broad, widening posteriorly, their tips separated when at rest, costal area very broad, the outer margin broadly rounded and beset with very fine, moderately long spines; subcostal area narrow, biseriate, discoidal area not reaching middle of elytra, broadest beyond middle, there six areolae deep, some of the apical nervelets embrowned, sutural area finely reticulated at base, becoming widely reticulated distally.

Length 4 65 mm, width, 1 45 mm.

Holotype (male), allotype (female), and paratype (female, broken), La Gloria, Costa Rica, altitude 900 feet, July 1931, M Valerio. Named in honor of the collector

This species is not easily confused with other North American members of the genus The long hairs, shape of paranota and elytra are distinguishing characters The lateral margins of elytra are beset with rather stiff bristly hairs, which are much shorter than the hairs on pronotum and carinae.

Corythucha omani, sp nov.

Similar to *C unifasciata* Champ but distinctly smaller and with the hood not so sharply constricted and the tumid elevations of elytra more roundly inflated Testaceous, a transverse band near base and some of the veinlets of hood, paranota, tumid elevation and sutural area and a few transverse nervures near apex of elytra infuscate Antennae moderately long, testaceous, beset with long bristly hairs; segment I about three times as long as II; III nearly two and one-half times as long as IV; the latter swollen toward the apex and mostly dark brown. Legs brownish, the tibiae and tarsi testaceous; rostrum extending to the metasternum.

Pronotum brown, finely pitted, moderately convex, tricarinate; lateral carinae rather short, raised anteriorly, not extending forward beyond base of triangular process; median carina foliaceous, mostly uniseriate, about one-half as high as the hood, the upper margin sinuate Hood moderately large, strongly inflated, constricted a little in front of middle, the hind portion

subglobose. Paranota large, four areolae deep, the outer margin beset with spines. Elytra distinctly narrowed posteriorly, beset with spines along the outer margins from the base to apical fourth; costal area triseriate, the areolae large and hyaline; tumid elevation plump, moderately large, dark. Wing a little longer than abdomen, whitish.

Length, 3.10 mm; width, 1 10 mm.

Holotype (male) and two male paratypes, Nogales, Ariz., October 23, 1937, P. W. Oman; allotype (female) and paratypes (male and female) Tucson, Ariz., August 1934, C. J. Drake. Named in honor of P. W. Oman, who is taking a very active interest in collecting and studying hemipterous insects.

ANTHROPOLOGY.—Relationships of an early Indian cranial series from Louisiana.[1] HENRY B. COLLINS, JR., Bureau of American Ethnology.

One of the most significant recent developments in Southeastern archeology has been the discovery in Kentucky, northern Alabama, and Tennessee of a nonagricultural, nonceramic, shell mound culture, the earliest thus far known in the area (Webb, 1939; Webb and Haag, 1939, 1940). The Kentucky sites that have been described are Indian Knoll and Chiggerville (Moore, 1916; Webb and Haag, 1939) on the Green River in Ohio County, and the Ward and Kirkland sites on Cypress Creek, a Green River tributary (Webb and Haag, 1940). The Alabama-Tennessee sites are situated on the Tennessee River; Lu° 86 and Ct^v 17, in the Wheeler Basin, have already been described (Webb, 1939), and reports on the Pickwick and Guntersville sites are in press or in preparation.

In Louisiana, Ford and Willey (1940) have recognized a similar early culture complex, the Tchefuncte, which preceded the Marksville (Hopewellian) stage. Some of the Tchefuncte sites are coastal shell middens, others are earth mounds in the interior; unlike the Kentucky sites, they all yield pottery.

The skeletal remains from these rather widely separated sites are of particular interest. Though by no means identical, the crania from Kentucky, Alabama, and Louisiana belong to the same general type, a type that differs in certain important respects from that of later inhabitants of the same areas. Measurements on Moore's Indian Knoll crania have been published by Hrdlička (1927), and the skeletal material from Chiggerville has been described by Skarland (1939). Newman and Snow are describing the skeletal remains from the Pickwick and Guntersville Basins and Snow those from the Louisiana shell middens. What I wish to do here is call attention to certain skulls

from Pecan Island, Vermilion Parish, southern Louisiana, which I excavated in 1926 (Collins, 1927), and which, from the later archeological investigations of Ford and others, are shown to have belonged to the Tchefuncte period.[2]

The Pecan Island series has been included in Hrdlička's latest catalog (1940) along with other Louisiana crania. Since they represent a sample of the earliest known Indian population in the Gulf area, it seems desirable to separate them from the other Louisiana crania and point out briefly their relationship to other southern and eastern cranial types.

The skulls were excavated from a burial ground (no village site in evidence) in a grove of young orange trees on the property of John Copell. The skulls were undeformed, and like the associated long bones, showed no evidence of pathology. Some of the bones rested on layers of red and yellow pigment. The following objects were found associated with the burials: Chipped stone knives and projectile points; hollow bone and antler projectile points with asphaltum in lower end to hold shaft; awls made of raccoon penis bones and deer cannon bones and ulnae; clam shells filled with asphaltum; distal end of an atlatl; "boat-stone" and rectangular stones (atlatl weights); tubular shell bead; drumfish teeth; large shell vessel (*Busycon perversum);* inner whorls of conch shells; raccoon and otter penis bones, some perforated; muskrat jaws; perforated dog teeth; worked pieces of turtle shell; and worked sections of dog jaws and teeth. No pottery was found with the burials; a few sherds of crude ware from the surface may represent a later period.

In addition to the Copell place two other sites were investigated on Pecan Island. (1) A group of low burial mounds on the Veazey place yielded fragmentary bones including some skulls with slight frontal flattening and long bones showing lesions apparently produced by syphilis. Cultural material from the Veazey site in part resembled Copell (red and yellow pigment with burials; asphaltum; bone awls and socketed projectile points; tubular shell bead; worked sections of dog jaws and teeth; raccoon and otter penis bones; and muskrat jaws). But there were other objects at the Veazey site such as spool-shaped ear ornaments of sheet copper and of slate covered with copper; woven textile, potsherds of Marksville type, stone celts, disk shell beads, perforated bear teeth, imitation bear teeth in shell, large finely chipped flint knife, and worked pieces of galena and hematite—traits that are

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[2] The cultural material from the site has been studied by Ford and Quimby and will be included in their report on the Tchefuncte culture.

diagnostic of the Hopewell culture, either as it exists in Ohio or in its southern manifestations, especially the Marksville of Louisiana and the Copena of northern Alabama. (2) At the third Pecan Island site, the Morgan place, were several large stratified mounds from which came skulls with pronounced fronto-occipital flattening and long bones showing evidence of syphilis. These highly deformed skulls, the nature of the mounds themselves, and the different type of pottery clearly indicated a cultural and temporal distinction between the Morgan and other sites; on the other hand, there seemed at the time no reason for separating Copell and Veazey, and I assumed them to have been contemporaneous (Collins, 1927).

Ford's later excavations in Louisiana and Mississippi and his analysis of potsherds from over 100 aboriginal sites in these States have thrown clearer light on the chronological relationship of the Pecan Island sites. Pottery analysis showed the Morgan mounds to belong to Coles Creek-Deasonville (the intermediate prehistoric culture stage in Louisiana and Mississippi) and Veazey to be somewhat earlier, since its pottery complex included Marksville sherds in addition to Coles Creek-Deasonville (Ford, 1936).

The artifacts from the Copell site, according to Ford and Quimby, are sufficiently like those from the Tchefuncte middens to be included in that complex. In some respects the Copell material is even closer to that from the Kentucky middens described by Moore (Indian Knoll) and Webb and Haag (Chiggerville and Cypress Creek). Without going into details here, I may state that the most striking and diagnostic Copell traits are also present at Indian Knoll and/or Chiggerville. The resemblances are such as to indicate a close cultural relationship, despite the considerable distance between central Kentucky and the Louisiana Gulf coast.

The exact relationship between the Copell and Tennessee-Alabama sites can not be known until we have Webb and DeJarnette's report on the Pickwick Basin excavations. However, the two sites from this area thus far described (Lu° 86 and Ct^v 17 in the Wheeler Basin; Webb, 1939) reveal fewer trait correspondences with Copell than do Indian Knoll and Chiggerville.[3]

In the first column of Tables 1 and 2 I have listed the means of

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[3] Webb and Haag (1940) find that the Kentucky shell mound sites share a number of features with Ritchie's Lamoka Lake site in New York, for which reason they suggest that the Kentucky shell mound complex be assigned to the Archaic pattern These resemblances, it might be pointed out, are of a general rather than specific character, few really diagnostic Kentucky traits are present at Lamoka and vice versa The relationship between Kentucky and Lamoka seems definitely more remote than that between Kentucky and Copell

measurements and indices of the Copell crania, calculated from the individual data given in Hrdlička's catalog (1940, pp. 434–436, 439–441). The series comprises 20 males and 13 females. One of the males listed in the catalog as Copell (No. 334223) came instead from the Veasey place and so is not included here. It might also be mentioned that the male skull in the deformed Louisiana series listed in the catalog as "Pecan Island" (No. 334251, p. 437) came from one of the Morgan mounds.

Following tabulation of the Copell means are columns showing the differences between these and the means of other southern and northern groups. The differences, whether plus or minus, are totaled and the average difference is given at the foot of the column. Measurements and indices are given separately, a necessary arrangement since two groups may show pronounced metrical differences and yet be very close indicially. The frequencies for all measurements and indices are given only for those series comprising the smallest numbers of skulls— the two Louisiana series, Chiggerville, the Lenape males, and New York females. To avoid unnecessary detail the only frequencies given for the other series are those for cranial length and index.

The groups selected for comparison are: (1) Those nearest geographically (Arkansas and other Louisiana); (2) the two culturally related Kentucky groups; and (3) those from Florida (Perico and Horrs Islands), the middle and upper Mississippi regions (Tennessee and Illinois), and the East and Northeast (Virginia, New York, New Jersey) that most closely approach Copell in skull form. The comparison brings out significant resemblances and differences with respect to cranial length and breadth, cranial height, face breadth, and orbital height.

In length and breadth of skull the Copell males stand midway between the southern and northeastern groups. They are considerably longer and with a few exceptions narrower headed than any other group from the Gulf region, though shorter and wider than the Algonkian-Iroquois type of the Northeast. The closest agreement in this respect is with western Virginia, where, as Hrdlička (1916) has pointed out, the skull form is intermediate between that of the North and South. The Virginia cranial index is identical with Copell, and the average difference of all measurements (1.98 mm) is smaller than for any other group.

The female Copell skulls are relatively much broader than the male. In this respect, and in most others, the females conform rather closely to the usual Gulf type, from which they differ only in having broader faces, somewhat broader noses, and lower and broader orbits.

Perhaps the most striking feature of the Copell crania is their great height. This is of especial interest because of the significance of this feature in America (Hrdlička, 1916, 1922, 1927, 1940; Stewart, 1940). Regarding height of the vault in the Southeast, Hrdlička (1940, p. 454) says:

The rest of the Gulf and neighboring States [except Texas] stand out in this important respect as a unit, characterized throughout by a relatively high vault With that of some of the Pueblos it is the highest, in crania of similar breadth and cranial index, on the North American Continent And we do not know as yet of such a broad high-headed large human group elsewhere

If we consider the Louisiana crania alone the situation is even more striking. In absolute height (basion-bregma) and mean height index the Copell males are exceeded slightly by the other Louisiana males, 11 in number. The combined total of all the Louisiana males shows a cranial height of 146.4 mm and a mean height index of 89.65. With the exception of two skulls from Pensacola Bay, Fla., they are higher headed than any other group from the Southeast, from the Pueblo region, Arctic, or Northeast—in fact, the highest of any human group thus far recorded. If the comparison be restricted to the six Copell males the results are much the same: two more samples of three skulls each, from Ross County, Ohio, and Indiana (Hrdlička, 1927, p. 47) equal Copell in mean height index (89.6) and the Indiana skulls slightly exceed them in absolute height (146.3 mm).

Though the Copell males have broad faces they are exceeded in this respect by most of the Floridians and by some of the Eskimo and Plains Indian groups. The face breadth of the five Copell females, on the other hand, is the largest recorded for females anywhere. The small size of the sample should be borne in mind, however. In face height, upper and total, the Copell females fall within the Southeastern range; they are consistently somewhat higher faced than the Algonkian and other Northeastern groups. For the males, measurements of total and upper facial height are available for only two and three individuals, respectively. These measurements, and the facial indices, are given in parentheses, but are not included in the average differences.

A striking feature of the Copell males is their low orbits. In this respect they stand entirely apart from the other southern Indians, while closely resembling the two prehistoric Kentucky groups and the Lenape. Their orbital height of 33.1 mm and index of 84.65 are likewise lower than the average for the Northeast where relatively low orbits prevail. Elsewhere in North America lower orbits than those of the Copell males are recorded only for the prehistoric Texas cave

dwellers, the two Kentucky series, and Manhattan and Long Islands, N. Y.

The Copell females are less pronounced in this respect, their orbits being somewhat higher, absolutely and indicially, than those of the males. However, they are still below the general average for the Southeast in absolute height, and their orbits being unusually broad, the index falls considerably below the Southeastern average. Most of the New England and other Northeastern females listed by Hrdlička (1927) have orbits that are somewhat lower in absolute height than those of the Copell females, but again the extreme orbital breadth of the latter results in a lower index.

It will be seen from Tables 1 and 2 that the Copell crania of both sexes tend to resemble the Gulf type (Florida, Arkansas, and other Louisiana) more closely in actual measurements than in indices. In contrast, the crania from Tennessee, Kentucky, Illinois, and Virginia, which are smaller in practically every dimension, are closer to Copell indicially than metrically. This is especially true of the skulls from Chiggerville and Indian Knoll, Ky. Since these are the smallest skulls thus far known east of the Mississippi, it is not surprising that there should be a sharp metrical contrast between them and the Copell crania, which in size and massiveness are above the average even for the Southeast. But despite the fact that the two Kentucky series are metrically farther removed from Copell than any of the other groups compared—with average differences of 4.39 mm and 4.01 mm for the males and 6.58 mm and 5.05 mm for the females—they are still very close indicially. This close similarity in cranial form would seem to indicate that the prehistoric Kentuckians and the Copell (Tchefuncte) people of southern Louisiana, both groups the earliest known in their respective localities and possessing a common culture, were likewise closely related physically. The great disparity in size might be explained, at least partially, on the basis of dietary differences. The food resources of the Louisiana Indians included both land and marine animals. According to present archeological evidence neither they nor the Kentucky shell mound Indians practiced agriculture. From the sea food they consumed—fish, mollusks, crustaceans—the Copell people would no doubt have received a more than adequate supply of calcium, phosphorus, and magnesium, the minerals most essential to bone development. It is known that marine fishes, oysters, crabs, and shrimps are excellent sources of these and other necessary minerals such as iodine, copper, and iron (Nilson and Coulson, 1939). As far as I am aware there is no information regarding the mineral and vitamin

content of the fresh-water mollusks and fishes of the Tennessee-Kentucky region, though deficiency in iodine, at least, may be assumed.

Newman (1939) and Snow (1940) report that the crania from the shell mounds in Pickwick and Guntersville Basins on the Tennessee River are very similar to those from Indian Knoll and Chiggerville.

In the Pickwick Basin skeletal material there are two main types represented The earliest stratigraphically is an undeformed dolichocranic type representing in unmixed form the southernmost extension of the general Eastern dolichocranic group, best exemplified by the so-called Northeastern Algonkins. The later intrusive deformed type links most closely with the Southeastern brachycranic group as seen in Tennessee, Arkansas, Louisiana and Florida skeletal series   .

The dolichocranic Shell Mound group in Pickwick Basin, taken as a whole, diverges somewhat from the pooled Northeastern and East-central Algonkin series in its smaller size, relatively higher vault, and shorter vertical facial diameters Within this group there is some evidence of a more gracile, smaller-headed variant and a more rugged, larger-headed variant The latter group more closely resembles the various more northerly dolichocranic series, whereas the former shows close affinities to even smaller and more gracile series from Ohio County, Kentucky These series are from Shell Mounds with pre-pottery horizons similar to the Pickwick sites (Newman, 1939)

The Copell people, with their low orbits and (in the males) a skull form bordering on dolichocrany, represent a still further extension into the South of what may be described as a generalized or modified Northeastern dolichocranic type. In some respects, however, such as the relatively broad skull of the females and the extreme cranial height and facial breadth in both sexes, the early Louisiana population diverges sharply from the Northeastern type and conforms to that of the Southeast. If we regard these southern features as evidence that the Copell people had already been subjected to local admixture we must assume that a brachycranic population had preceded them in the Gulf region. Of this, however, there is no evidence. On the contrary, wherever it has been possible to distinguish between earlier and later peoples in the Southeast, long heads are found to have preceded the broad heads (Newman, 1939; Snow, 1940) just as they usually have in other parts of America. Moreover, it seems unlikely that mixture with some hypothetical early population embodying the essential characteristics of the historic Gulf type should have resulted in a blend that exhibited such typical southern features as extreme cranial height and facial breadth in even more pronounced form than they are usually found today; or, on the other hand, in orbits not only much lower than those of the southern Indians but lower on the average than those in the Northeast.

It seems more likely that in the Copell crania we have a sample of an early population that, with later admixture, gave rise to the his-

TABLE 1.—COMPARISON OF COPELL AND OTHER SOUTHERN AND EASTERN CRANIA—MALES

Measurements and indices	Louisiana[1] (Copell)	Louisiana[1] (non-Copell)	Arkansas[3]	Florida[1] (Horn Island)	Florida[1] (Perico Island)	Tennessee[1]	Kentucky[1] (Indian Knoll)	Kentucky[1] (Chiggerville)	Illinois[1]	Virginia[1]	New Jersey[2] (Lenape)	New York[2]
Cranial length	(20) 186.3	(14) −4 6	(38) −9 6	(33) −1 4	(37) −3 0	(23) −6 9	(34) −6 3	(24) −5 2	(30) −3 3	(29) −2 7	(12) +0 2	(19) +2.9
Cranial breadth	(20) 141.4	(14) +4 9	+1 4	+5 4	+4 4	−1 4	−5 6	(24) −7 2	−2 3	−2 1	(12) −2 5	−1.2
Cranial height	(6) 146.0	(11) +0 6	−4 4	−2 1	−4 8	−2 2	−6 5	(4) −6 5	−3 9	−3 5	(8) −6 3	−7 5
Cranial module	(6) 157.3	(11) +0 6	−3 7	+1 8	0 0	−1 9	−6 3	(5) −5 9	−2 5	−2 6	(8) −2 4	−1 4
Menton-nasion	(2) 122.5	(5) (+0 9)	(+0 8)	(+4 7)	(+3 7)	(+2 5)	(−6 8)	(8) (−12 2)	(+0 9)	(+4 5)	(5) (−1 1)	(−1.3)
Alveolar point-nasion	(3) 73.0	(3) (+5 1)	(+1 8)	(+4 3)	(+2 8)	(+1 7)	(−2 6)	(3) (−3 9)	(+1 8)	(+0 7)	(5) (−2 4)	(−0 1)
Face breadth	(8) 144.0	(9) +3 1	−5 2	+3 8	+2 4	−5 1	−8.0	(3) −6 3	−3 5	−3.3	(5) −5 2	−3.0
Orbit height, mean	(9) 33.1	(9) +3 6	+2 3	+3 1	+3 2	+0 7	−0 5	(6) −0 6	+2 1	+0 9	(5) +0 2	+1 2
Orbit breadth, mean	(9) 39.1	(9) +2 1	+0 1	+0 8	+0 6	−0 5	−1 0	(7) −0 5	+0 7	−0 5	(5) −0 5	0 0
Nose height	(5) 54.0	(10) −0 1	−0 8	+1 0	−1 2	−1 6	−3 1	(13) −3 7	−0 7	−1 0	(5) −3 1	−2 1
Nose breadth	(5) 26.0	(11) +0 8	+0 5	+0 6	−0 7	−0 3	−2 2	(9) −0 2	−0 5	+1 2	(5) +0 5	+1.1
Average difference of measurements		2 27	4 00	2 22	2 26	2 29	4 39	4 01	2.16	1 98	2 32	2 27
Cranial index	(20) 75.90	(14) +4 6	(38) +4 9	(33) +3 5	(37) +3 7	(22) +2 1	(34) +0 8	(23) −1 6	(30) +0 1	(29) 0 0	(12) −1.5	(19) −1.8
Mean height index	(6) 89.60	(11) +0 8	−2 9	−2 3	−3 9	−0 4	−0 6	(4) −1 1	−1 4	−1 0	(8) −3 6	−5 4
Height-breadth index	(11) 103.50	(11) −2 9	−4 1	−5 9	−6 7	−1 4	−0 8	(4) +0 8	−1 3	−1 1	(8) −2 9	−4.7
Facial index, total	(2) 86.25	(5) (+2 8)	(+2 7)	(+0 8)	(+0 4)	(+4 1)	(−1 6)	(3) (−6 1)	(+1 5)	—	(5) (+1 3)	(−0 4)
Facial index, upper	(3) 50.96	(7) (+2 3)	(+2 8)	(+1 5)	(+1 0)	(+2 6)	(+0 7)	(3) (+0 6)	(+2 5)	(+1 3)	(5) (−0 1)	(+0 2)
Orbital index, mean	(9) 84.65	(9) +4 5	+5 6	+6 0	+6 9	+2.7	−0 3	(5) −1 5	+3 9	+3 6	(5) +1 6	+3 1
Nasal index	(5) 48.16	(10) +1 5	+1 7	+0 2	−0 3	+0 9	−1 3	(9) +2 2	−0 1	+3 0	(5) +3 9	+4 0
Average difference of indices		2 86	3 84	3 58	4 30	1 50	0 76	1 44	1 36	1 74	2 70	3 80

[1] Hrdlička, 1940   [2] Hrdlička, 1927   [3] Skarland, 1939

TABLE 2.—COMPARISON OF COPELL AND OTHER SOUTHERN AND EASTERN CRANIA—FEMALES

Measurements and Indices	Louisana[1] (Copell)	Louisana[1] (non-Copell)	Arkansas[1]	Florida[1] (Horr Island)	Florida[1] (Perico Island)	Tennessee[1]	Kentucky[2] (Indian Knoll)	Kentucky[3] (Chiggerville)	Illinois[2]	Virginia[1]	New Jersey[1] (Lenape)	New York[1]
Cranial length	(13) 174.4	(16) −4.3	(52) −7.5	(35) +2.1	(60) +0.3	(37) −4.5	(26) −4.1	(13) −1.9	(39) −2.7	(28) +3.1	(22) +0.8	(18) +2.8
Cranial breadth	(13) 139.8	(16) 0.0	−1.4	−0.1	+1.3	−4.0	−9.0	(12) −9.0	−4.9	−4.3	−8.2	(18) −4.8
Cranial height	(2) 137.0	(13) +1.1	−0.2	−4.3	−0.7	−0.2	−5.8	−5.0	−1.5	−1.5	−6.7	(16) −6.1
Cranial module	(2) 151.5	(13) −2.7	−4.1	−3.8	−0.9	−4.1	−7.4	(6) −6.2	−4.0	−1.9	−5.7	(16) −3.8
Menton-nasion	(5) 116.4	(9) −2.2	−0.8	+1.6	+3.3	−0.5	−11.5	(6) −8.9	−0.3	−0.9		(9) −4.1
Alveolar point-nasion	(5) 70.8	(13) −0.2	+0.5	+1.2	+0.8	−0.9	−7.2	(6) −4.5	−2.7	−3.1	−2.6	(13) −1.6
Face breadth	(5) 138.6	(11) −6.7	−9.8	−4.4	−1.9	−12.4	−14.1	(2) −12.6	−12.1	−7.4	−12.1	(11) −7.2
Orbit height, mean	(9) 33.7	(10) +1.1	+1.6	+1.6	+1.1	+0.1	−1.2	(6) −0.6	+0.5	−0.7	+0.2	(15) 0.0
Orbit breadth, mean	(9) 39.0	(10) −0.9	−1.6	−0.4	−0.5	−2.5	−2.5	(7) −1.2	−1.1	−1.6	−1.0	(15) −1.2
Nose height	(5) 51.4	(13) −1.4	−0.7	−0.8	−1.3	−1.9	−5.4	(6) −3.6	−2.0	−1.4	−2.5	(15) −1.1
Nose breadth	(5) 26.8	(11) −1.5	−1.4	−2.5	−1.8	−1.6	−4.2	(5) −2.0	−0.9	+0.2	−1.3	(15) −0.1
Average difference of measurements		2.01	2.24	2.07	1.26	2.97	6.58	5.05	2.97	2.37	4.11	2.96
Cranial index	(13) 80.11	(16) +2.1	(52) +2.8	(35) −0.9	(60) +0.7	(37) −0.2	(26) −3.1	(12) −4.7	(39) −1.5	(28) −3.8	(22) −5.0	(18) −3.9
Mean height index	(2) 86.35	(13) +3.3	+3.2	−0.9	0.0	+3.2	+0.9	(6) +0.6	+2.1	+0.1	−1.4	(16) −2.6
Height-breadth index	(2) 97.35	(13) +0.6	+1.4	−1.9	−0.5	+3.6	+2.9	(6) +3.9	+3.1	+2.6	+1.7	(16) −0.4
Facial index, total	(4) 84.60	(6) +2.6	+6.1	+2.6	+3.3	+6.7	0.0	(1) (+3.2)	+6.3	+3.9		(9) +1.4
Facial index, upper	(4) 51.80	(4) +1.5	+3.8	+1.7	+0.8	+3.7	+0.1	(1) (+0.9)	+1.6	+0.6	+1.4	(11) +1.1
Orbital index, mean	(9) 86.45	(10) +4.8	+7.8	+5.0	+4.1	+6.3	+2.6	(4) −1.1	+3.9	+1.9	+2.9	(15) +2.9
Nasal index	(5) 52.10	(11) −0.8	−2.0	−4.1	−2.2	−1.2	−2.7	(5) +0.1	+0.4	+1.9	+0.2	(15) +0.9
Average difference of indices		2.24	3.87	2.44	1.66	3.56	1.76	2.08	2.70	2.11	2.10	1.89

[1] Hrdlička, 1940   [2] Hrdlička, 1927   [3] Skarland, 1939

toric Gulf type. Since the males on the whole show closer physical affinities with Kentucky, Tennessee, Virginia, Illinois, and the Northeast than with the Southeast, it would seem that the origin of the early Gulf type should be sought in that direction. The Copell people should, apparently, be regarded as the southernmost and in some respects most divergent and specialized representatives of a once widespread Indian type east of the Mississippi, a long-headed and rather high-headed type that in one form or another was characteristic of the earliest known culture horizons in the Northeast, Kentucky, Tennessee, and northern Alabama.

The affinities of the later brachycranic type in the Southeast seem to lie in the opposite direction, probably in eastern Mexico, as Hrdlička (1922, pp. 117, 131) has suggested. Though the paucity of comparative data for Mexico prevents demonstration of this point, it appears not unlikely that herein may lie the explanation of the process of brachycephalization that seems to have occurred generally throughout the Southeast. The brachycranic Gulf type would seem best explained as a blend between the earlier coastal population, of Northeastern origin, and a later broad-headed strain which probably entered the Southeast from Mexico. Such a hypothesis finds support in the evidence of strong cultural influences from Mexico, most of which, as Phillips (1940) shows, have been received in relatively late prehistoric times. Artificial cranial deformation was doubtless one of the culture traits thus introduced from Mexico. The custom was not practiced in the Northeast nor by the early southern groups which we have been considering (Stewart, 1940; Snow, 1940). It was, however, present in Mexico, Middle America, and Peru from the earliest known times, and it was evidently from this direction that it later spread to the Southeast and Mississippi Valley.[4]

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[4] The fact that cranial deformity is so rarely encountered in peninsular Florida would seem to preclude the possibility that the custom had reached the Southeast by way of the Antilles

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

43D ANNUAL MEETING

The 43d Annual Meeting of the Washington Academy of Sciences was held in the Assembly Hall of the Cosmos Club, January 16, 1941, with 46 members present. President Eugene C. Crittenden called the meeting to order at 9:40 P M The minutes of the 42d Annual Meeting were presented and approved as published in the Journal.

Report of the Corresponding Secretary

The Corresponding Secretary, Frederick D. Rossini, submitted the following report on the membership and activities of the Academy:

During 1940, there was a total of 59 persons (31 resident and 28 nonresident) elected to membership. Of these, 43 accepted membership, 10 declined, and 6 did not reply. Of those accepting membership, 8 were elected in recognition of their work in plant pathology, 6 in entomology, 5 in forestry, 4 in biology, 2 in agronomy, 2 in medicine, 2 in zoology, 2 in physics, and 1 each in botany, chemistry, cytology, dentistry, geology, helminthology, horticulture, parasitology, physiology, plant physiology, meteorology, and soil science.

Because of their retirement from active work, 12 members (6 resident and and 6 nonresident) were placed on the "retired" list to enjoy all the privileges of membership without further payment of dues Resignations were accepted from 14 members in good standing (10 resident and 4 nonresident). One nonresident member permitted his membership to lapse through nonpayment of dues for two years and was dropped from the rolls.

During 1940, there occurred the deaths of the following 12 members (6 resident and 6 nonresident):

GEORGE C MATSON, Tulsa, Okla., January 3, 1940.
FREDERICK G TRYON, Washington, D C , February 15, 1940.
DAVID M. MOTTIER, Bloomington, Ind , March 25, 1940.
CYRUS ADLER, Philadelphia, Pa , April 7, 1940.
THOMAS A. GROOVER, Washington, D. C , April 20, 1940.
FREDERICK E. FOWLE, Washington, D C , April 23, 1940
FRANCIS R. HAGNER, Washington, D C , July 7, 1940.
WILLIAM BOWIE, Washington, D. C , August 28, 1940.
WILLIAM LASH MILLER, Toronto, Canada, September 1, 1940.
EDWARD B MEIGS, WASHINGTON, D. C , November 5, 1940.
RAYMOND PEARL, Baltimore, Md., November 17, 1940
WALTER J. YOUNG, Fredericksburg, Va , November 23, 1940.

On January 1, 1941, the membership of the Academy was distributed as follows:

	Resident	Nonresident	Total
Regular	417	131	548
"Retired"	31	13	44
Honorary	3	14	17
Patrons	—	3	3
TOTAL	451	161	612

On that date there were 34 vacancies in the resident and 19 in the nonresident list. As a result of elections to membership made by the Board of Managers on January 10, 1941, and of nominations presented to the Board on that day, there are potentially only about 20 vacancies in the resident and 14 in the nonresident list.

During the period from February 9, 1940, to January 10, 1941, the Board of Managers held seven meetings, with an average attendance of 17 persons During the year, the Board authorized the appointment by the President of the following special committees:

1 Committee to consider revising the bylaws with regard to the two Nonresident Vice-Presidents. H. L. CURTIS (chairman), C. THOM, P. C WHITNEY. Work completed.

2. Committee to consider the printing contract for the JOURNAL: F. G. BRICKWEDDE (chairman), H G. AVERS, R W BROWN, C. L GAZIN, J. H. KEMPTON, R. J. SEEGER, and J. A STEVENSON Work completed.

3. Committees on awards for scientific achievement, for 1940: AUSTIN H. CLARK, General Chairman.

For the biological sciences. A H CLARK (chairman), F O COE, J. M. COOPER, H A EDSON, E A. GOLDMAN, I T. HAIG, C F. W MUESEBECK, H. W. SCHOENING, G. STEINER, and A. WETMORE.

For the engineering sciences: F. M DEFANDORF (chairman), C. H. BIRDSEYE, H. L. CURTIS, H. G. DORSEY, H N. EATON, A. C. FIELDNER, H. C. HAYES, G. W. MUSGRAVE, and W. N. SPARHAWK.

For the physical sciences: O H. GISH (chairman), A. K. BALLS, F. S. BRACKETT, W. E. DEMING, H E McCOMB, F. L. MOHLER, W. T. SCHALLER, J. H TAYLOR, O. R WULF, and E. G. ZIES. Work of the committees completed.

4. Committee to consider the provision of a meeting place for the Acad-

emy when the Cosmos Club moves. The President (chairman), the Corresponding Secretary, and the Chairman of the Committee on Meetings. Work not completed.

5. Committee to consider the archives of the Academy: N R SMITH (chairman) and F. D. ROSSINI. Work completed

6. Committee to consider societies for affiliation with the Academy. F. M SETZLER (chairman), R E GIBSON, and R. R SPENCER. Work not completed

7. Committee of Tellers to count the ballots on three amendments to the bylaws: H. N. EATON (chairman), B J. MAIR, and R S JESSUP Work completed.

8 Committee to consider problems of the JOURNAL relating to the number of copies to be printed and of back numbers and volumes to be bought and sold: the Custodian of Publications (chairman), the Senior Editor, and the Treasurer Work completed

On motion it was voted to accept the Corresponding Secretary's report and to place it on file

Report of the Recording Secretary

The Recording Secretary, FRANK C. KRACEK, presented the following report.

The 43d year of the Academy began with the 296th meeting and ended tonight with the 302d meeting. All the seven meetings of the year were held in the Assembly Hall of the Cosmos Club.

The 296th meeting was held on February 15, 1940 An illustrated address was given by GEORGE GAYLORD SIMPSON of the Department of Paleontology, American Museum of Natural History in New York City, on the subject *Mammals and land bridges* The address was subsequently published in the JOURNAL Attendance 123

The 297th meeting, which was held on March 21, 1940, was memorable for being the first presentation by the Academy of awards for scientific achievement Three awards were presented on this occasion, in the fields of biological, engineering, and physical sciences

The award in Biological Sciences was received by HERBERT FRIEDMANN of the U S National Museum, in recognition of his researches and publications in the field of *Ornithology* Dr FRIEDMANN was introduced by ALEXANDER WETMORE, Assistant Secretary of the Smithsonian Institution

The award in Engineering Sciences was presented to PAUL A SMITH of the U S Coast and Geodetic Survey, in recognition of his contributions to knowledge of the *Ocean bottom along the eastern coast of the United States*. The recipient was introduced by LEO OTIS COLBERT, Director of the U S Coast and Geodetic Survey.

The award in Physical Sciences was received by WILMOT H BRADLEY, of the U. S Geological Survey, in recognition of his contributions on the *Oil shale of the Green River formation in Wyoming*. Dr. Bradley was introduced by GERALD F. LOUGHLIN, Chief Geologist of the U S Geological Survey.

Certificates of award were presented by EUGENE C. CRITTENDEN, President of the Academy The recipients responded by brief addresses concerning their work Attendance 83.

The 298th meeting was held on April 18, 1940. The Academy was addressed on the subject *Science and Democracy* by WALDEMAR KAEMPFERT, Science Editor of the New York Times. Attendance 82.

The 299th meeting was held on October 17, 1940. W. F. G. SWANN, Mem-

ber of the Academy and Director of the Bartol Research Foundation of the Franklin Institute spoke on *Laws of nature*, especially emphasizing the extent to which the laws of physics are creations of the mind. Attendance 78.

The 300th meeting was held on November 28, 1940. The subject *Human side of the census* was discussed by VERGIL D REED, Assistant Director of the Bureau of the Census. Attendance 87.

The 301st meeting was held as a joint meeting with the Botanical Society of Washington on December 19, 1940. An illustrated address on the *Conquest of the land* was delivered by W. C LOWDERMILK, Member of the Academy and Assistant Chief of the U. S. Soil Conservation Service. The speaker emphasized the role man's use of the land plays in its erosion and illustrated his theme by lantern slides of depleted land in a number of historic areas. Attendance 92

The 302d meeting was held on January 16, 1941. The address was given by the retiring President of the Academy, EUGENE C. CRITTENDEN, Assistant Director of the National Bureau of Standards, who spoke on the *Progress in the measurement of light*, summarizing the steps that have been taken in recent years toward the establishment of a logical basis for the precise measurement of light, and the relation of such measurements to the usefulness of light under various conditions of vision. Attendance 59.

On motion it was voted to accept the Recording Secretary's report and to place it on file

Report of the Treasurer

The Treasurer, HOWARD S RAPPLEYE, presented the following financial statement of the accounts of the Academy:

CASH RECEIPTS AND DISBURSEMENTS

RECEIPTS:

From back dues	$ 150 00
From dues for 1940	2491.00
From dues for 1941	130.00
From subscriptions for 1939	2 50
From subscriptions for 1940	593.28
From subscriptions for 1941	274.80
From sales of JOURNALS	113.15
From sales of directory	1.40
From payments for reprints	357.71
From interest on deposits	86 92
From interest on investments	896.50
Total receipts.	5097.26
Cash balance January 1, 1940	1018.49
Cash received from Interborough bond	25.00
To be accounted for	$6140.75

DISBURSEMENTS:

For Secretary's office, 1939	$ 66.45
For Secretary's office, 1940	449.99
For Treasurer's office, 1940	223 04
For JOURNAL printing, 1939	236.91
For JOURNAL printing, 1940	2314.23
For JOURNAL reprints, 1939	25.66
For JOURNAL reprints, 1940	485.29
For illustrations, 1940	391.21
For Custodian and Subscription Manager	41.77
For JOURNAL office, 1939	20.77
For JOURNAL office, 1940	241.97
For Meetings Committee, 1939	121.30
For Meetings Committee, 1940	274.55
For dues returned to retired members	10.00

Bank debit memos, as follows

Dues, 1940	$ 0.25	
Dues, 1941	.80	
Subscriptions, 1940	75	
Subscriptions, refunded	3 15	
Interest on investment	25 22	
		30.17
Deposited in savings account		86.92
Total disbursements		5020 23
Cash balance December 31, 1940		1120.52
Total accounted for	.	$ 6140.75

RECONCILIATION OF BANK BALANCE

Balance as per cash book, December 31, 1940		$1120.52
Bank Balance, American Security & Trust Co		
per statement of December 31, 1940		1098 34
Receipts not deposited		120 80
		1219.14

Checks outstanding, not cashed

No 170	$21 50	
669	8.00	
670	9 66	
671	2 20	
672	5.63	
673	7.34	
674	44.29	98.62
Balance		$1120 52

Check No. 170 listed as outstanding was issued in May, 1934, but has not been cashed

INVESTMENTS

409	shares stock of Washington Sanitary Improvement Co , par value $10 per share, cost.	$4090.00
20	shares stock Potomac Electric Power Co., 6 per cent Pref., cost .	2247.50
*4	certificates Corporate Stock of the City of New York, 1 for $500 and 3 for $100, cost	800.00
**1	Bond of Chicago Railways Co , No. 1027, interest at 5 per cent, due 1927; par value $1000 less $250; cost	713.87
1	real-estate note of T. Q. Donaldson (No. 6 of 12) dated June 26, 1937 (extended for 3 years); interest 5 per cent, cost	1000.00
2	real-estate notes of Yetta Korman et al , dated October 5, 1938, for 3 years. (No 7 of 37 for $500, and No. 8 of 37 for $500); cost. .	1000.00
3	real-estate notes of Ell & Kay Bldg Investment Co , dated October 15, 1938, for 3 years. (No 75 of 165 for $2000, No 83 of 165 for $1000, and No. 101 of 165 for $1000); interest at 5 per cent, cost .	4000.00

Butler notes—property at 1707 L Street NW , bought in by note holders—Academy's share 4/250ths; interest amounting to $20.00 received in 1940; cost	2000.00
	15,851.37
Deposited in savings account, American Security & Trust Co	8496 86
Cash book balance December 31, 1940	1120.52

Total Assets		$25,468.75
Total Assets Dec. 31, 1939	$25,474 80	
Total Assets Dec 31, 1940	25,468.75	
Net change for 1940	$−6 05	

* The certificates of the Corporate Stock of the City of New York were received in exchange for the Interborough Rapid Transit Co bond as a result of the unification of the Interborough Rapid Transit Co and the Manhattan Railway Co which have both passed to the public ownership of the City of New York. The amount of $10 00 was received in interest on the Interborough bond and $25 00 was paid on the investment

** The bond of the Chicago Railways Co was not paid upon maturity due to the expiration of franchise and failure of the Legislature to enact continuing legislation, interest has been paid to date under the authority of the Courts, and $250 has been paid on the principal since maturity

ALLOTMENTS

	Allotted		Expended
Secretary's office	. $ 450.00.	..	$ 449.99
Treasurer's office	. . 225.00	..	223.04
JOURNAL	2500.00+receipts		
	1341.44 = 3841 44		3432.70***
Meetings Committee	350.00		274.55***
Custodian and Subscription Manager	120.00		41.77
Membership Committee.	10.00		———
Executive Committee.	10.00		———

Report of the Auditing Committee

The Auditing Committee, H E. McComb (chairman), L. V. Berkner, and F. S. Brackett reported:

"Your committee appointed to audit the accounts of the Treasurer of the Washington Academy of Sciences for the year 1940 submits the following report:

"The Treasurer's records of receipts and expenditures as shown in his account books and included in his report have been examined and found correct.

"All vouchers have been examined and found to be correct and properly approved.

"The balance sheets submitted by the bank and the securities listed in the Treasurer's report have been examined. The statement of the assets of the Academy was found correct.

"The records of the Treasurer's office have been carefully and systematically kept, thus greatly facilitating the work of the auditing committee.

"The auditing committee congratulates the Treasurer on the manner in which he has carefully conducted his office during his term of office."

It was moved to accept the reports of the Treasurer and the Auditing Committee and to place them on file By vote it was so ordered

Report of the Board of Editors

The Board of Editors, C. Lewis Gazin, James H Kempton, and Raymond J Seeger, reported as follows:

Volume 30 for the year 1940 consisted of 12 issues amounting to 548 pages, 12 pages less than Volume 29 but equaling Volume 27 It contained 67 original articles. Of these 34 were by members of the Academy and 33 were communicated. Leading papers of general interest were obtained for 6 issues. Original papers were illustrated by 64 linecuts and 28 halftones. In several instances papers contained illustrations in excess of the number allowed and these were paid for either by the author or by an interested member. Space in volume 30 was distributed as follows:

```
 2 papers in Anthropology totaling  22 9 pages or  4 2 per cent
 2 papers in Biochemistry totaling  13 9 pages or  2 5 per cent
20 papers in Botany       totaling 122 6 pages or 22 4 per cent
 5 papers in Chemistry    totaling  39.4 pages or  7 2 per cent
 7 papers in Entomology   totaling  46 3 pages or  8 5 per cent
 2 papers in Geology      totaling  33 2 pages or  6 1 per cent
 2 papers in Ichthyology  totaling   8 5 pages or  1 0 per cent
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*** Bills outstanding, not paid, at end of year (estimated)· JOURNAL, $327 72; Meetings Committee, $46 25.

1 paper	in Malacology	totaling	2 0 pages or	0 4 per cent
1 paper	in Mycology	totaling	6 5 pages or	1 2 per cent
1 paper	in Ornithology	totaling	12 5 pages or	2.3 per cent
5 papers	in Paleobotany	totaling	29 6 pages or	5 4 per cent
6 papers	in Paleontology	totaling	57 1 pages or	10 4 per cent
13 papers	in Zoology	totaling	71 8 pages or	13 1 per cent

9 Obituaries with 7 2 pages, Scientific Notes and News with 0 9 page, and Index with 6 9 pages occupied together 15 0 pages or 2 7 per cent The Proceedings of the Academy and affiliated societies occupied 60 4 pages, distributed as follows·

The Academy.	22 3 pages
Anthropological Society	1 2 pages
Botanical Society	6 5 pages
Chemical Society	2 8 pages
Geological Society	14.0 pages
Philosophical Society	13 0 pages

The amount allocated by the Academy to printing, engraving, distribution and for reprints of the JOURNAL was $2200 00 plus receipts The total of receipts from the JOURNAL, including subscriptions, sale of back numbers, charges to authors for excess illustrations, corrections and reprints collected during 1940 is $1341 44, giving a total income to the JOURNAL for printing, etc., of $3541 44.

The total cost of printing, engraving, and distribution and of reprints of the JOURNAL for 1940 was $3453 30. The unexpended balance is $88.14.

The amount allocated by the Academy to expenses of the Editor's office was $300 00 The amount expended by this office was $262 74, leaving an unexpended balance of $37 26 The total unexpended balance from printing, etc , and from the Editor's office is $125 40

The report of the Board of Editors was accepted and ordered placed on file.

Report of the Custodian and Subscription Manager of Publications

The following report was submitted by the Custodian and Subscription Manager of Publications, W W. DIEHL·

In this, the first year of the office, the duties have been chiefly that of custodianship concerned first with locating the stocks, then with their inventory and storage. There is appended herewith a summarized inventory of stocks on hand.

All the stocks, except those of the JOURNAL, Volumes 22 to 29 inclusive, at Menasha, Wis., are now stored in Washington Since March 16 when certain stocks previously kept in Baltimore, Md , were moved to Washington there have been no storage costs

The campaign for new subscribers to the JOURNAL planned for initiation in September was necessarily deferred until late in December because the unforeseen shortage of current stocks at that time precluded any possibility of filling additional subscriptions for Volume 30. This shortage in Volume 30 has been most helpfully alleviated through the aid of the President and of certain other members of the Academy in obtaining copies by personal solicitation. Immediate demands have, therefore, been met thus far.

Because of the deferment of the campaign for new subscribers the amount actually expended for the necessary work, chiefly postage and correspondence, was $47.77 leaving an unexpended balance of $72.23.

Nonmember subscribers in the United States	93
Geological Society of Washington	23
Nonmember subscribers in foreign countries	52
	——
	168

SUMMARY OF INVENTORY OF SALABLE STOCKS OF PUBLICATIONS OF THE WASHINGTON ACADEMY OF SCIENCES ON DECEMBER 31, 1940

PROCEEDINGS OF THE WASHINGTON ACADEMY OF SCIENCES·

Vols 1 to 13, incl	50 sets complete

JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES

Vols 1 to 15, incl	1 set complete
	7 sets incomplete
Vol 16 .	28 complete
17	33 complete
18	28 complete
19	27 complete
20	23 complete
21	68 complete
22	47 complete
23	40 complete
24	40 complete
25	86 complete
26	77 complete
27	51 complete
28	30 complete
29	24 complete
30	9 complete

A miscellaneous collection of odd numbers of the Proceedings, the JOURNAL, Red Books, and special publications relating to World War No 1 is also on hand

By vote the report of the Custodian and Subscription Manager of Publications was accepted and placed on file.

Report of the Tellers

The report of the Tellers, GEORGE W. VINAL (chairman), J. W McBUR-NEY, and W G. BROMBACHER was read by the Corresponding Secretary The following officers were declared elected:

President	AUSTIN H CLARK
Secretary	FREDERICK D ROSSINI
Treasurer	HOWARD S RAPPLEYE
Board of Managers	{ FRANK H H ROBERTS, JR FERDINAND G BRICKWEDDE HENRY B COLLINS, JR }

The Corresponding Secretary read the list of nominations for Vice-Presidents submitted by the affiliated societies as follows:

Philosophical.	HAROLD E. McCOMB
Biological	ERNEST P WALKER
Chemical	RAYMOND M HANN
Entomological .	AUSTIN H CLARK

National Geographic ..   ALEXANDER WETMORE
Geological   .. ...   JOSEPH T. PARDEE
Medical   ....   FRED O. COE
Historical   .   ALLEN C. CLARK
Botanical   . ...   MELVIN C MERRILL
Archiological   . .   ALEŠ HRDLIČKA
Washington Engineers   PAUL C WHITNEY
Electrical Engineers   HARVEY L CURTIS
Mechanical Engineers   WALTER RAMBERG
Helminthological . .   JESSE R. CHRISTIE
Bacteriological   .   LELAND W PARR
Military Engineers   .   CLEMENT L GARNER
Radio Engineers   .   JOHN H DELLINGER

By vote of the Academy, the Recording Secretary was instructed to cast one ballot for the list as read This was done and the Vice-Presidents were declared duly elected

Report of the Committees on Awards for Scientific Achievement

The President announced that the Committee on Awards for Scientific Achievement reported as follows.

The Subcommittee for Biological Sciences reported no nomination for the year 1940.

The Subcommittee for the Engineering Sciences recommended that a certificate of award be conferred on—

HARRY DIAMOND, Principal Physicist in the Radio Section of the National Bureau of Standards, for his work in the *development of methods and apparatus for the "blind-landing" of aircraft, in the development of methods and apparatus for obtaining meteorological data from appropriately equipped balloons sent into the atmosphere and in the development of an automatic weather-reporting station*

The Subcommittee for the Physical Sciences recommended that a certificate of award be conferred on—

FERDINAND G BRICKWEDDE, Chief of the Cryogenic Laboratory of the National Bureau of Standards, for his work in *taking part in the discovery of Deuterium, in determining the physical properties of the various isotopic forms of the hydrogen molecule, and in establishing a working temperature scale for the range $14°$ to $83°K$*

As business from the floor, remarks were made by L B TUCKERMAN concerning the lack of care exercised by some members in marking their ballots, particularly that portion in which preference is expressed by a numerical choice for election by the Hare system Remarks were made also by R E GIBSON

President CRITTENDEN announced the appointment of NATHAN R SMITH as Archivist for the Academy, to serve for 3 years.

President CRITTENDEN, after thanking the officers and committees who served with him during the year, appointed Past Presidents C E CHAMBLISS and CHARLES THOM to escort President-elect CLARK to the chair. After a short address President CLARK declared the meeting adjourned at 10:40 P.M

FRANK C. KRACEK, *Recording Secretary.*

366TH MEETING OF THE BOARD OF MANAGERS

The 366th meeting of the Board of Managers was held in the Library of the Cosmos Club on Friday, February 7, 1941 President CLARK called the meeting to order at 8:10 P.M., with 15 persons present, as follows: A H. CLARK,   F. D. ROSSINI,   H. S. RAPPLEYE,   N. R SMITH,   W. W. DIEHL, F. H H ROBERTS, JR ,   F. G. BRICKWEDDE,   H. B. COLLINS, JR.,   R M HANN, M C. MERRILL, H. L. CURTIS, L W. PARR, C L. GARNER, and, by invitation, F M SETZLER and F. C KRACEK.

The minutes of the 365th meeting were read and approved.

President CLARK announced the following appointments: Senior Editor of the JOURNAL, for 1941, J H KEMPTON; Member of the Board of Editors of the JOURNAL, for 1941, 1942, and 1943, G A COOPER; Associate Editor of the JOURNAL, representing the Biological Society, for 1941, 1942, and 1943 H. A. REHDER; Associate Editor of the JOURNAL, representing the Geological Society, for 1941, 1942, and 1943, EDWIN KIRK, Associate Editor of the JOURNAL, representing the Botanical Society, for 1941, 1942, and 1943, CHARLOTTE ELLIOTT, Members of the Executive Committee for 1941 (in addition to the President, Secretary, and Treasurer), H L CURTIS and J. E GRAF, to the Committee on Monographs, for 1941, 1942, and 1943, C L GAZIN and F C BISHOPP, to the Committee on Membership for 1941, F. C KRACEK (chairman), W G BROMBACHER, W. F FOSHAG, C. F W MUESEBECK, J H STEWARD, P A SMITH and L. E YOCUM.

The Executive Committee, A H CLARK, chairman, presented the following proposed budget, with estimated receipts, for 1941

Proposed Budget for 1941

Secretary . .		$ 450.00
Treasurer		225.00
Custodian and Subscription Manager of Publications		120.00
Committee on Meetings		350.00
Committee on Membership		10.00
JOURNAL:		
For printing, engraving, mailing, reprints	$3100.00*	
For clerical assistance to the Senior Editor	240.00	
For postage and miscellaneous expenses	60.00	3400 00
Total regular budget	.	4565.00
Publication of the Directory of the Academy for 1941		350.00
Grand Total		$4915.00

Estimated Receipts for 1941

Membership dues for 1941	.	2900.00
Membership dues for previous years		100.00
Interest and Dividends		1083.42
Subscriptions to the JOURNAL	.	855.80
Total		$4939.22

* Does not include services to be charged to, and paid for by, authors or their sponsors

The Board approved this budget for 1941.

The Executive Committee recommended that the President appoint a committee of two persons, one to be the Treasurer, to survey the Academy's investments and deposits and to make appropriate recommendations to the Executive Committee.

The Committee on Membership, F C. KRACEK, chairman, presented nominations for membership for five persons, all resident.

The Board considered individually and duly elected to membership the eight persons (five resident and three nonresident) whose nominations had been presented on January 10, 1941.

The Committee to Consider Societies for Affiliation with the Academy, F. M SETZLER, chairman, recommended that the Committee be dissolved and that its existing assignment to investigate several societies for affiliation be abandoned, because the Committee felt that any Society desirous of affiliating with the Academy should present its request to the Academy on its own initiative The Board approved this recommendation to dissolve the Committee and abandon its assignment

The Secretary presented the following information with regard to changes in membership since the last meeting of the Board: Deaths, none, acceptances to membership, 11; retirements, 1; resignations, 3 The status of the membership, as of February 7, 1941, was as follows:

	Regular	Retired	Honorary	Patrons	Total
Resident	415	33	3	0	451
Nonresident	125	14	14	3	156
Total	540	47	17	3	607

The Secretary reported receipt of two nominations for Vice-Presidents of the Academy for 1941: F M. SETZLER, to represent the Anthropological Society of Washington, W. A DAYTON, to represent the Washington Section of the Society of American Foresters. The Board elected Messrs SETZLER and DAYTON to be Vice-Presidents of the Academy for 1941 to represent the Societies indicated

The Board authorized the President to appoint a Committee to Consider the Publication of a Directory of the Academy for 1941

The meeting adjourned at 9.30 P M.

303D MEETING OF THE ACADEMY

The 303d meeting of the Academy was held jointly with the Philosophical Society of Washington in the Assembly Hall of the Cosmos Club at 8:15 P M on Thursday, February 20, 1941, with President A H CLARK presiding H E McCOMB, Vice-President of the Academy representing the Philosophical Society, introduced the speaker, P. W BRIDGMAN, Hollis Professor of Mathematics and Natural Philosophy at Harvard University, who delivered an address entitled *The changing position of thermodynamics*

Professor Bridgman pointed out that thermodynamics was formulated at a time when there was no knowledge or experimental control of the details of atomic or molecular processes, reexamined the fundamental concepts of energy and entropy, and indicated what is their present status

There were about 180 persons present. The meeting adjourned at 9:30 P.M. for a social hour.

FREDERICK D. ROSSINI, *Secretary.*

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington at its annual meeting held January 21, 1941, elected the following officers for the ensuing year President, FRANK M. SETZLER; Vice-President, JULIAN H STEWARD, Secretary, REGINA FLANNERY; Treasurer, T DALE STEWART; Members of the Board of Managers, GEORGE S. DUNCAN, WILLIAM N. FENTON, HERBERT KRIEGER, RUTH UNDERHILL, WALDO R. WEDEL.

A report of the membership and activities of the Society since the last annual meeting follows

Membership:

Life members	. . .	2
Active members		39
Associate members .		12
Total		53

The members elected during the year were. ANDREW J KRESS, active member, and WILLIAM H. GILBERT, associate member Lost through death was CYRUS ADLER, an active member of long standing.

The Treasurer's report is as follows

Funds invested in Perpetual Building Association (interest for last half of 1940 not included)	$1542.36
21 shares Washington Sanitary Improvement Co (par value $10 per share)	210 00
2 shares Washington Sanitary Housing Co (par value $10 per share)	200 00
Cash in bank .	647 45
Credit with American Anthropological Association	5 00
	$2604 81
Bills outstanding.	
To American Anthropological Association	$ 75 00
Total	$2529 81
Total as of 1/15/40	2354 36
Increase	$ 175 45

The supply of the following numbers of the American Anthropologist, old series, is now completely exhausted. Vol 1, nos 1–3, vol 3, no 1; vol 4, 1–4; vol. 5, nos 1, 2, 4; vol 9, no 2

Papers presented before the regular meetings of the Society were as follows

January 16, 1940, 690th meeting, JOHN M COOPER, *The Gros Ventres, a Plains Indian theocracy*

February 20, 1940, 691st meeting, FREDERICK W KILLIAN, *Cultural determinants of the law*

March 19, 1940, 692d meeting, W H GILBERT, *Eastern Cherokee life and culture.*

April 16, 1940, 693d meeting, HENRY B COLLINS, JR , *Some problems of Eskimo prehistory,* the address of the retiring president.

October 15, 1940, 694th meeting, WILLIAM N FENTON, *The place of the Iroquois in the prehistory of America*

November 19, 1940, 695th meeting, L S CRESSMAN, *Early cultures of south-central Oregon*

December 17, 1940, 696th meeting, F H DOUGLAS, *White influence in Indian art.*

REGINA FLANNERY, *Secretary*

GEOLOGICAL SOCIETY

580TH MEETING

The 580th meeting of the Society was held at the Cosmos Club, January 10, 1940, President J. T. PARDEE, presiding

Informal communications.—M. I. GOLDMAN compared pits in eroded pebbles of diorite porphyry and sandstone from the Henry Mountains, Utah, with similar phenomena in the granite of Corsica; and reviewed a number of theories for their origin.

Program.—W. S. BURBANK: *An area of pseudo-landslide topography in the San Juan Mountains, Colorado.* A so-called landslide topography covering 5 to 6 square miles in the Red Mountain mining district was described, and evidence presented to show that the topography is mainly the result of differential abrasion by a mountain glacier along a zone of faulted and highly altered rocks.

The mining district lies along the northwest border of a large volcanic basin of subsidence. Zones of step-faulting and alteration along this edge of the basin provided a zone of weakness followed by the main drainage valley and by one of the trunk glaciers of the Wisconsin stage. The ice of the trunk glacier was moving parallel to the closely spaced faults and fissures, and as a result of differences in resistance to abrasion between altered and unaltered rocks, the surface was abraded into a series of troughs and ridges, and typical roche moutonée.

Small débris slides or avalanches sliding directly across these corrugations after the glacial period shattered some of the narrower and weaker ridges, partly covered them, and generally masked the true nature of the post-Wisconsin topography.

It was shown that previous interpretations of the extent of landsliding were untenable, (1) because much of the so-called landslide surface was glaciated and highly sculptured bedrock along the channel of the trunk glacier, and (2) because at many places numerous shafts and tunnels driven during mining operations were in solid bedrock and had failed to encounter conditions expectable according to the landslide interpretation

L W CURRIER: *Geologic features of Lowell quadrangle, Massachusetts.*

F. W. LEE: *Contouring bedrock in a glaciated region by seismic methods*

581ST MEETING

The 581st meeting of the Society was held at the Cosmos Club, January 24, 1940, President J. T. Pardee, presiding

Program.—D F HEWETT: *The appraisal of metal reserves.*

R J ROBERTS: *Mercury deposits of the Bottle Creek district, Nevada.*

E N GODDARD: *Manganese deposits of the Philipsburg district, Montana.*

582D MEETING

The 582d meeting of the Society was a joint meeting with the Washington Academy of Sciences, at the Cosmos Club, February 15, 1940, the President of the Academy, E. C. CRITTENDEN, presiding. President J. T. PARDEE, of the Geological Society, introduced the speaker.

Program.—GEORGE G. SIMPSON: *Mammals and land bridges.* (Published in this JOURNAL 30: 137–163 Apr. 15, 1940)

583D MEETING

The 583d meeting of the Society was held at the Cosmos Club, February 28, 1940, President J. T. PARDEE, presiding.

Informal communications.—R. W BROWN reviewed *The Mizpah coal field, Custer County, Montana,* by F. S. PARKER and DAVID A. ANDREWS, and *Relationship between floras of type Lance and Fort Union formation,* by ERLING DORF, in their bearing on the Cretaceous-Paleocene boundary problem in the Rocky Mountain region.

Program —L. W STEPHENSON. *Summary of faunal studies of the Navarro group of Texas.*

JULIA GARDNER: *The general relationships of the Midway fauna.*

W. W. RUBEY and K. J. MURATA. *Chemical evidence bearing on origin of a group of hot springs.* A compact group of thermal springs 2½ miles north of Auburn, Lincoln County, Wyo., just east of the Idaho line, discharges water and gas through more than a hundred vents The mean annual temperature of the region is about 5°C., but the water ranges from 20° to 60°C. The total discharge of water is estimated at 2 4 liters per second (38 gallons per minute) and that of gas at 0.86 liters per second under standard conditions of temperature and pressure.

The springs rise through old travertine deposits at the edge of valley fill and along a sharp anticline formed during "Laramic" folding. No igneous rocks are exposed nearby, but Auburn lies only a short distance south and east of the extensive Tertiary and Quaternary volcanics of Idaho and Yellowstone Park

For preliminary study, two water samples, one from a hot and the other from a relatively cold spring, and two gas samples, likewise from a hot and a cold spring, were collected and analyzed

The two water samples are very similar in composition but the hotter one is less concentrated with all components other than dissolved carbon dioxide and hydrogen sulphide The large amount (about 3,000 p p m) of sodium chloride in both samples is probably derived from salt beds in Jurassic rocks nearby. Small amounts of boron, arsenic, and ammonium compounds, substances commonly exhaled from volcanic fumaroles, are present in both waters.

Carbon dioxide is the predominant constituent of both gas samples, and appreciable amounts of hydrogen sulphide are also present The sample of cooler gas contains more nitrogen and oxygen than the hotter one. The ratio of carbon dioxide to hydrogen sulphide is essentially the same in both samples These two gases are common as volcanic emanations and characterize later phases of volcanism.

Quantitative relationships of water and gas composition and of temperature in these springs seem to call for a significant contribution (about 5 per cent) of steam from an underlying magma, such as Allen and Day found necessary to explain the hot springs of the Yellowstone Magmatic steam containing minor amounts of carbon dioxide, hydrogen sulphide, and volatile compounds is conceived as condensing upon contact with a cool moderately saline ground water charged with atmospheric gases. This would account for cool, relatively concentrated water from some vents and hot, less concentrated water from others, for cool gas rich in nitrogen and oxygen from some vents and hot gas rich in carbon dioxide and hydrogen sulphide from others. Estimates of heat dissipated from these hot springs lead to the conclusion that a small Quaternary intrusion, several cubic miles in volume, along a

preexistent fracture zone but reaching no nearer to the surface than a mile or two, could explain all the observed phenomena.

584TH MEETING

The 584th meeting of the Society was held at the Cosmos Club, March 13, 1940, President J. T. PARDEE, presiding.

Program.—E. L. STEPHENSON: *Geophysical and geological investigations of the Casper Mountain chromite deposit, Wyoming.* The Casper Mountain chromite deposit is located on the summit of Casper Mountain in Natrona County, Wyo., 11 miles by road south of the city of Casper. A magnetometer survey of the deposit was made by the Geological Survey in 1938–39, when 8,281 stations were occupied with an Askania vertical variometer. Later in 1939, under the program of strategic minerals investigations, the Bureau of Mines sampled the deposit by trenching and diamond drilling, and the Geological Survey prepared detailed topographic and geologic maps and core logs The program included 7,432 feet of sampling trenches and 3,624 feet of inclined diamond drill holes

The deposit consists of a nearly vertical, roughly tabular body of chromite-bearing talcose schist 2,500 feet long and 100–450 feet wide, and several nearby smaller bodies As shown by drilling, the depth of the schist exceeds 500 feet. The chromite occurs in the schist as irregular lenses and bands of small crystals and as disseminated small crystals The surrounding rocks are quartz-monzonite, pegmatite, metadiorite, amphibolite, and quartz-mica schist It is thought that the talcose schist and associated rocks occur as roof pendants in the quartz-monzonite

Strong characteristic magnetic anomalies occur over the chromite-bearing schist, and were used to outline the main schist body as well as to select advantageous sites for diamond drill holes and sampling trenches. Laboratory studies of the rock samples later were used to make more complete interpretations of the magnetic anomalies Owing apparently to an excess of iron in the chromite molecule, the Casper Mountain chromite is found to be much more paramagnetic than ordinary chromite, some of the specimens closely approximating magnetite in magnetic permeability No evidence has so far been found of magnetite associated with the chromite in the talc schist, unless some of the most strongly magnetic specimens are to be regarded as highly chromiferous magnetites rather than unusually magnetic chromites Specimens selected in the field as samples of magnetite were found on analysis to contain 13 per cent or more of Cr_2O_3

No attempt was made to predict from the magnetic anomalies the amount of chromite in the schist. However, a close agreement was found between the shape and dip of the main schist body as predicted from the magnetometer measurements and as determined by drilling and trenching.

S B HENDRICKS: *Base exchange and properties of clays*

585TH MEETING

The 585th meeting was held at the Cosmos Club, March 27, 1940, President J. T PARDEE, presiding.

Program —EARL INGERSON: *Fabric criteria for distinguishing pseudoripple marks from ripple marks*

R. H JAHNS: *Postglacial flood history of the Connecticut River in Massachusetts.*

T. A. HENDRICKS· *Structure of the western part of the Ouachita Mountains, Oklahoma.*

586TH MEETING

The 586th meeting was held at the Cosmos Club, April 10, 1940, President J. T. PARDEE, presiding

Informal communications.—W. J. WOODRING reported that fossils of three different ages are found in a tar deposit in the Santa Maria district, California

C. F. STEWART SHARPE reported on a proposed field conference on buried organic matter under Piedmont soils at Spartanburg, S. C., April 24, 1940.

Program.—G. R MANSFIELD: *The role of fluorine in phosphate deposition.* In earlier studies of phosphate deposition attention has centered on the accumulation of phosphorus Here it is shown that some agent, probably fluorine, is necessary to render the phosphate insoluble enough to be preserved through geologic ages. Although fluorine is steadily supplied to the oceans by the weathering and erosion of rocks containing fluorine-bearing minerals, additional large supplies are furnished from time to time by volcanism. It appears significant in this connection that volcanic products accumulated in great quantity in proximity to the regions where the principal phosphate deposits of the United States were laid down and at the time when these deposits were formed. Thus it is thought that volcanism, as a source of fluorine, may have been an indirect though determinative factor in their origin Volcanism and unconformities are no doubt related to deep-seated causes within the earth The principal phosphate deposits of the United States lie above unconformities of greater or less extent.

J G BROUGHTON· *Structural comparison of pre-Cambrian and Paleozoic rocks in northwestern New Jersey* The area studied includes a portion of the most northwesterly of the pre-Cambrian gneiss ridges, as well as the New Jersey extension of the Pennsylvania slate belt (Martinsburg) Field relations indicate that the gneisses have developed their structures as a result of primary flowage and that the ridges are elongate domes which pitch to the southeast. Sander diagrams indicate that the lineation is the "b" axis

The slate belt has been divided into a northern area in which the structures are identical with those described from Pennsylvania South of this is another area in which fracture cleavage is the dominant structure The writer believes that this cleavage has been developed as a result of stresses attendant on thrust faulting and that in its strongest development it has become almost a new flow cleavage Yielding of quartz during the formation of cleavages is discussed with Sander diagrams

R H SARGENT: *Problems in the production of topographic maps*

587TH MEETING

The 587th meeting was held at the Cosmos Club, April 24, 1940. President J. T. PARDEE, presiding

Informal communications —TAISIA STADNICHENKO reported a publication of the Biogeochemical Laboratory of the Russian Academy of Science giving analyses of coals and marine organisms showing concentrations of rare elements. C S ROSS discussed chalcedony fillings in modular masses from Madison, Oreg.

Program —C B HUNT· *Mode of emplacement of stocks in the Henry Mountains, Utah, and its significance in the interpretation of laccoliths.*

T. P. THAYER: *Chromite deposits of the Strawberry Range, Oregon.* The Strawberry Range in Oregon is eroded from an east-west anticline connecting the Ochoco and Blue Mountains The chromite deposits occur in two main belts of ultramafic rocks intruded into ancient crystalline and Mesozoic sedimentary rocks exposed in the central portion of the range.

Chromite has been mined east of Canyon City, where it occurs in comparatively fresh unsheared ultramafic rocks in which the original mineralogic and textural features are preserved. Planar and linear structures are commonly present, and are best shown in the chromite deposits. The borders of the ultramafic mass are pyroxenitic, and the chromite deposits occur as irregular lenses in the less pyroxenitic and more dunitic central portion.

The Cr_2O_3 content of the chromite ranges from 33 to 52 per cent and is apparently not the same in any two deposits. Serpentinised dunite most commonly forms the matrix of the ore, which is probably of early magmatic origin. In places dikes of gabbro and related pegmatite cut the chromite and enclose angular fragments of ore. The gabbro seems to have been altered by the agencies that serpentinised the ultramafic rocks, and therefore probably antedates the serpentinisation.

About 20,000 tons of chromite, a quarter of which was high-grade ore, have been shipped from the district. Most of the readily accessible deposits of high-grade chromite have been mined out, and future production will be predominantly of low-grade concentrating ore containing from 15 to 30 per cent of chromic oxide. The indicated reserve is about 80,000 tons of ore, and with sufficiently high prices, probably 200,000 tons of concentrating ore can be mined from known deposits.

W. C. LOWDERMILK· *Notes on erosion in North Africa.*

588TH MEETING

The 588th meeting of the Society was held at the Cosmos Club, November 27, 1940, President J T. PARDEE, presiding

Informal communications.—J. J FAHEY reported on two rare minerals in the Green River deposits of western Wyoming—shortite and bradleyite, the latter a new mineral.

Program.—W E. POWERS: *Multiple glaciation of Mauna Kea, Hawaii.*

P. S. SMITH: *Trends of Alaska mineral production.*

W. T. SCHALLER: *A photographic technique for emphasizing mineral relations in hand specimens.*

589TH MEETING

The 589th meeting of the Society was held at the Cosmos Club, December 11, 1940, President J. T. PARDEE, presiding.

Program.—J. T. PARDEE: *Unusual currents in Glacial Lake Missoula.*

48TH ANNUAL MEETING

The 48th Annual Meeting was held immediately following the 588th regula meeting. The reports of the secretaries, treasurer, and auditing committee were read and approved.

Officers for the year 1941 were then elected, as follows:

President· J B. REESIDE, JR.

Vice-Presidents: L. H. ADAMS, W. W RUBEY.

Treasurer: ALICE S. ALLEN.

Secretary: W. S. BURBANK

Council: D A. ANDREWS, G. A. COOPER, JULIA GARDNER, EARL INGERSON, K. J. MURATA.

The Society nominated J. T. PARDEE to be a Vice-President of the Washington Academy of Sciences for the year 1941.

ROLAND W. BROWN, *Secretary.*

PALEONTOLOGY.—*Generic descriptions of Upper Paleozoic Bryozoa.*[1]　R. S. BASSLER, U. S. National Museum.

This is the first of several short contributions in which the writer proposes to describe and illustrate the genotypes of some new or imperfectly known genera of fossil Bryozoa. In the author's *Index and bibliography of genera and genotypes of Bryozoa*, comprising Part 67 of the *Fossilium catalogus* published by W. Junk at The Hague, 1934, the systematic position of the described genera was suggested. Since then special efforts have been made to study either the types or typical specimens, with the result that in many cases illustrations of their internal structure can now be offered.

The death of Dr. George H. Girty in 1939 precluded further work on the many invertebrates he had described without illustration in his article *New genera and species of Carboniferous fossils from the Fayetteville shale of Arkansas,*[2] wherein descriptions only of eight new bryozoan genera of Trepostomata and Cryptostomata from this Mississippian formation were given. Short diagnoses of these genera and notes upon *Stenopora* Lonsdale and *Nemataxis* Hall, genera of earlier date, with illustrations of their internal structure, form the subject of the present paper. The type specimens of Dr. Girty's Fayetteville shale Bryozoa are missing, but the thin sections of the genotypes studied by him are still available. Thus further work on the various species is still necessary, but the sections will serve for the illustration of the generic characteristics. Furthermore, Dr. Girty's descriptions are so very detailed that for present purposes short diagnoses emphasizing the essential generic characteristics in addition to the illustrations are sufficient.

Order TREPOSTOMATA (family BATOSTOMELLIDAE Ulrich, 1890)

Genus Stenopora Lonsdale, 1844[3]

The recent discovery of a well-preserved example of the genotype in the national collections has permitted the illustration of the true internal char-

acters of this genus, namely, the presence of strongly beaded zooecial walls
and of a large and a small set of acanthopores, the lack of mesopores, and the
practical absence of diaphragms of any nature. Formerly *Stenopora* was held
for species with perforated diaphragms. Then with Lee's work in 1912,[4] the
genus was restricted to ramose forms with complete diaphragms, and *Tabuli-
pora* Young, 1883, was recognized for the species with perforated ones. In
1929, the present author, misled by the original illustrations and descriptions
of *Stenopora* and by the prevailing opinion of authors, proposed the genus
Ulrichotrypa for ramose species in which diaphragms were absent. Now, as
shown here in figs. 5, 6, the internal structure of *S. tasmaniensis* is the same
as that described for *Ulrichotrypa*, thus reducing the latter to synonymy.

Genotype: *S tasmaniensis* Lonsdale, 1844. Permian of Tasmania. (Figs.
5, 6.)

Genus Amphiporella Girty, 1911 (*op. cit., p. 199*)

Zoarium of large tortuous solid flat fronds in which the zooecia proceed in
opposite directions from a middle plain but not from a median plate as in
typical bifoliate species. Zooecial structure with strongly moniliform (beaded)
walls as in typical *Stenopora* but differing in the occurrence of perforated
diaphragms and numerous mesopores. In tangential sections acanthopores of
medium size are seen at the junction of the walls and a connecting row of
granules occurs along the line of zooecial contact. The frondose growth and
mesopores alone distinguish *Amphiporella* from *Tabulipora*, features perhaps
of no generic importance

Genotype: *A. maculosa* Girty, 1911 Fayetteville shale, vicinity of Fayette-
ville, Ark. (Figs. 3, 4)

Genus Coeloclemis Girty, 1911 (*op. cit, p 201*)

Described as a new subgenus under probably *Anisotrypa* although the ge-
nus is not mentioned, thin sections of the genotype, *C tumida*, indicate a
zoarium of hollow epithecated stems formed by a single layer of zooecia, with
internal zooecial structure similar to *Anisotrypa* except that well-developed
acanthopores occur and diaphragms of all kinds are absent. Vertical sections
show a very short immature region with the tubes bending abruptly out-
ward into an equally short mature zone, a structure so similar to certain
Cryptostomata that it is possible that future discoveries may show that the
genus is incorrectly placed in the Batostomellidae. At present, however,
Coeloclemis is considered the same as *Anisotrypa* save that clearly outlined
acanthopores occur usually at the zooecial junctions and the walls in tangen-
tial sections show a single or double row of small granules.

4 LEE, G W , Mem Geol Surv Great Britain, Paleontology, 1(pt. 3): 135–195,
pls 14–16 1912

Figs 1, 2 —*Pycnopora regularis* Girty: Tangential and vertical sections, ×30,
illustrating the untabulated mesopores and perforated diaphragms   Figs 3, 4.—
Amphiporella maculosa Girty. Tangential and vertical sections, ×30, showing acan-
thopores, beaded walls, perforated diaphragms, and numerous mesopores   Figs 5, 6 —
Stenopora tasmaniensis Lonsdale· Tangential and vertical sections, ×30, showing
beaded walls, absence of diaphragms, and occurrence of two sets of acanthopores are
shown Figs 7-9 —*Coeloclemis tumida* Girty. Vertical section, ×4½, and part of the
same ×30 (7, 8), and tangential section, ×30 (9) exhibiting characters as in *Aniso-
trypa* save that acanthopores are developed and diaphragms are wanting   Figs. 10-
12.—*Syringoclemis biserialis* Girty. Tangential sections (10, 11) the first near the base
of mature region illustrating cryptostomatous shape of mature zooecium, and the
second in the most mature portion, ×20, with vertical section, ×20 (12) showing ab-
sence of hemisepta and diaphragms.
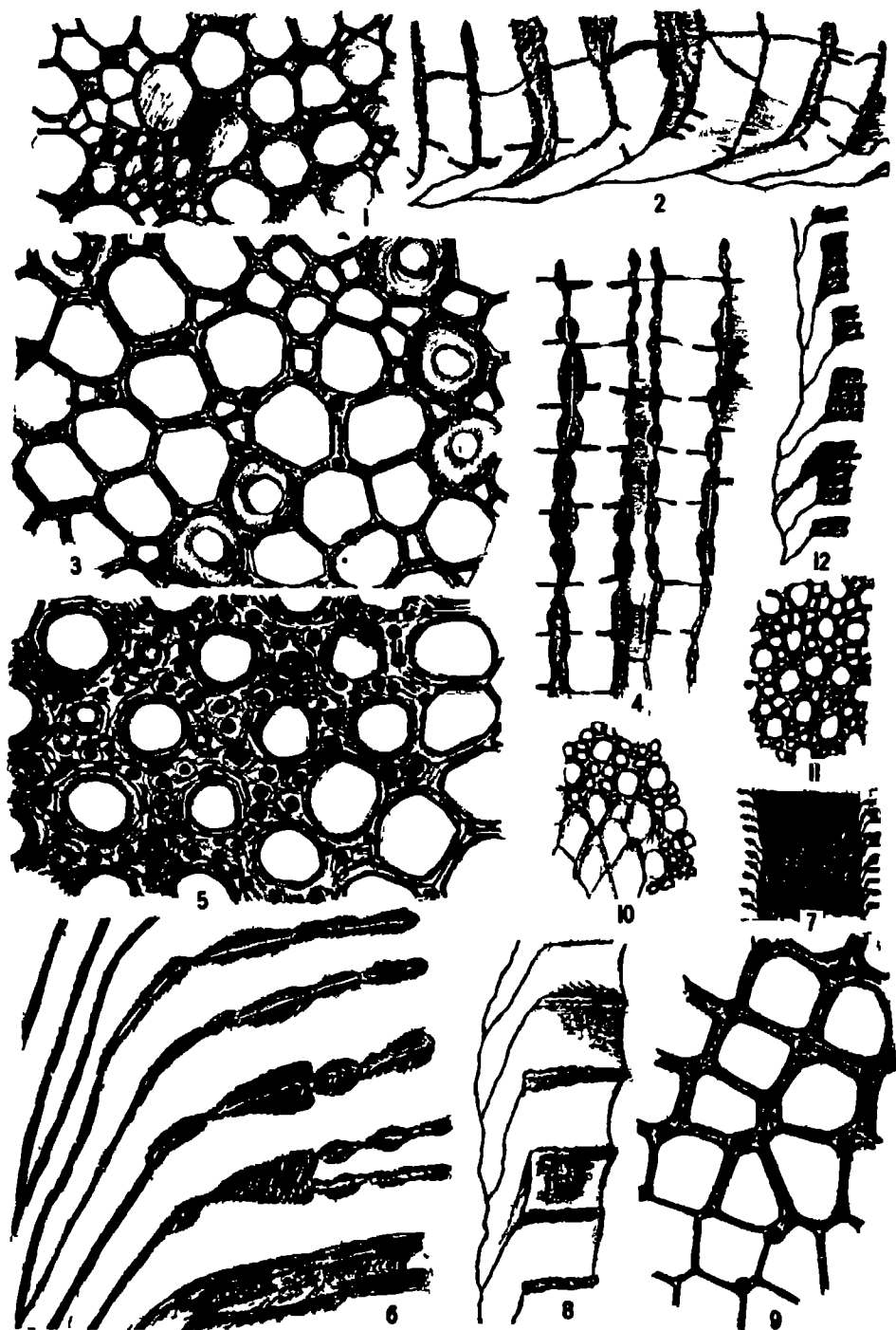
Figs 1-12 —(See opposite page for explanation)

Genotype: *C. tumida* Girty, 1911. Fayetteville shale, vicinity of Fayetteville, Ark. (Figs. 7–9.)

Genus **Callocladia** Girty, 1911 (*op. cit.*, p. 212)

As noted by Dr. Girty, the classification of this genus depends upon the interpretation of the type of structures in the zooecial cavity. Should these prove to be hemisepta the correct generic position would be in the Rhabdomesontidae, but if they are perforated diaphragms the genus belongs to the Batostomellidae. More thin sections are necessary before this can be determined with certainty although the large acanthopores and stenoporoid wall structure indicate relationship to the Batostomellidae. The vertical thin section (Fig. 22) although the best observed does not prove that either a superior hemiseptum is located nearly opposite an inferior one or that these two plates are only opposite sides of a perforated diaphragm. At present it seems more correct to regard *Callocladia* as an *Anisotrypa* because of its hollow cylindrical branches and lack of beaded walls, but differing in having mesopores and acanthopores.

Genotype: *C. elegans* Girty, 1911 Fayetteville shale, vicinity of Fayetteville, Ark. (Figs 21, 22)

Genus **Pycnopora** Girty, 1911 (*op. cit.*, p. 202)

Dr. Girty states that this group, proposed as a subgenus of *Lioclema* and consisting of the genotype *P. regularis* and two other species, differs in its thin lamellar zoarial expansion and in its greatly reduced number of mesopores and its smaller acanthopores. Semidiaphragms not always opposite each other but probably representing centrally perforated diaphragms, and apparently untabulated mesopores with undulating walls, are additional and more important characters marking the group as one of generic importance. *Callocladia* (figs 21, 22) should be compared in the study of this genus.

Genotype: *P. regularis* Girty, 1911. Fayetteville shale, vicinity of Fayetteville, Ark (Figs. 1, 2.)

Genus **Stenocladia** Girty, 1911 (*op. cit.*, p 204)

This group, likewise proposed as a subgenus under *Lioclema*, seems to be worthy of generic rank as it has the wall structure, acanthopores, and mesopores of that genus differing, however, in a supposed bifoliate method of growth and especially with both zooecia and mesopores untabulated In tangential sections of the genotype and only known species, *S. frondosa*, mesopores are comparatively few in the outer part of the mature region. They are visible in the lower part of the mature zone but later become filled with striated tissue and develop rows of small granular acanthopores in the outer part

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Figs 13, 14 —*Nemataxis fibrosus* Hall: Tangential and vertical sections, ×30, showing occurrence of hemisepta and parallel rows of granular acanthopores   Figs. 15–17.—*Idioclema insigne* Girty   Tangential section, ×30, illustrating very large acanthopores indenting the walls (15); vertical sections of a young (16) and a mature specimen (17), ×30, showing the superior and inferior hemisepta.   Figs 18–20 —*Dyscritella robusta* Girty· Tangential sections, ×20 (18) through a macula composed of thick walled mesopores; similar section (19), ×30, showing structure of the usual zooecia and acanthopores; vertical section (20), ×20, illustrating absence of diaphragms in both the mesopores and zooecia   Figs 21, 22.— *Callocladia elegans* Girty: Tangential and vertical sections, ×20, with mesopores and acanthopores but otherwise as in *Anisotrypa*.   Figs. 23, 24 —*Stenocladia frondosa* Girty: Tangential section, ×30, illustrating the minute acanthopores (23); vertical section, ×30, showing bifoliate growth and absence of diaphragms in both mesopores and zooecia (24)
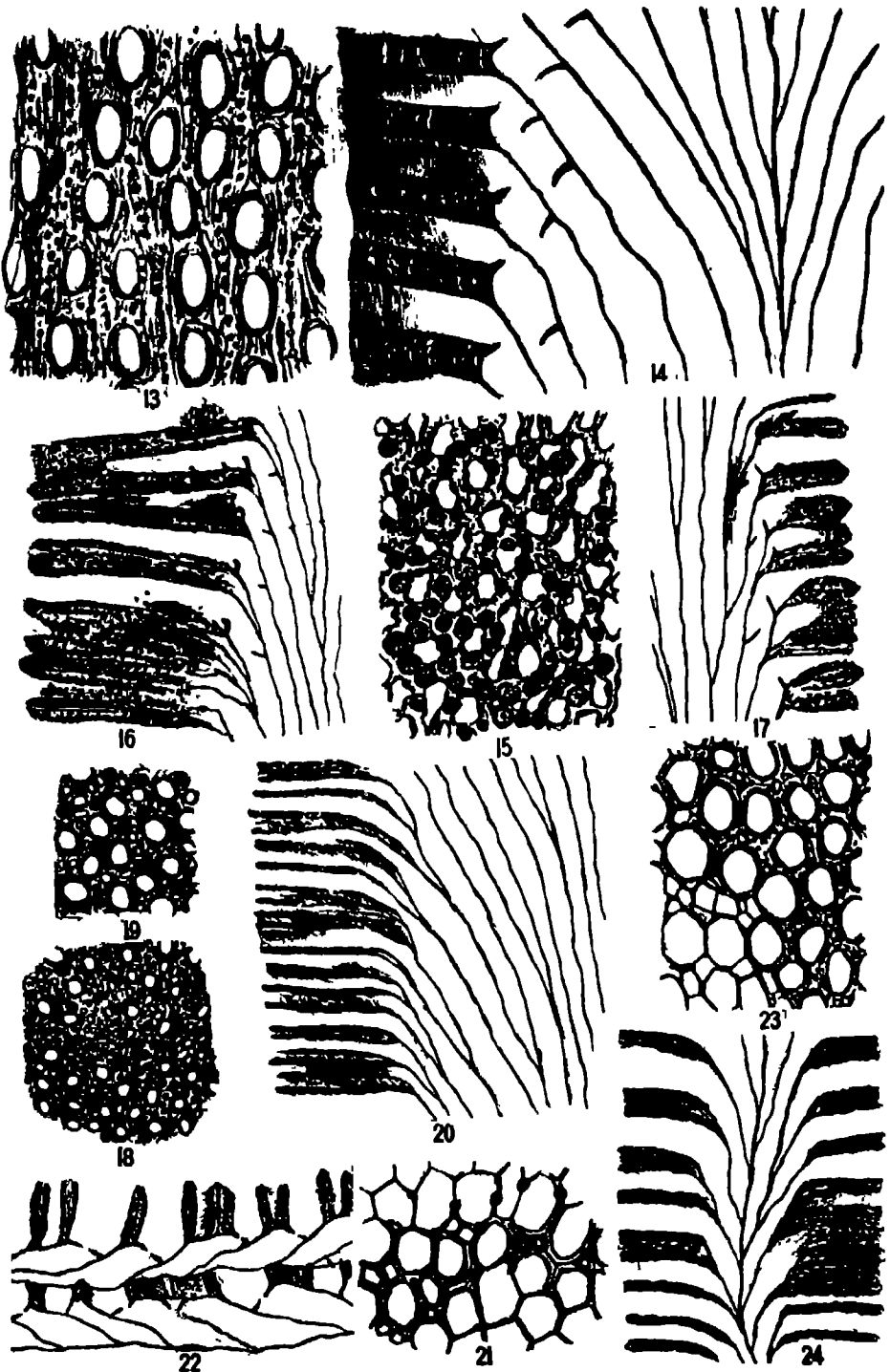
Figs. 13–24 —(See opposite page for explanation.)

of same. More specimens are necessary to prove that the so-called median plate exists, namely, that the zooecia arise back to back and proceed out in opposite directions, or that they simply form flattened fronds. Some of the acanthopores show tabulae.

Genotype: *S. frondosa* Girty, 1911. Fayetteville shale, vicinity of Fayetteville, Ark. (Figs. 23, 24.)

Genus Dyscritella Girty, 1911 (*op. cit.*, p. 193)

Two ramose species, possessing numerous acanthopores and mesopores and the unbeaded wall structure of *Lioclema* but differing in that diaphragms are entirely absent in both the zooecia and mesopores, were assigned here by Dr Girty who proposed the name as a subgenus under either *Batostomella* or *Lioclema*. The characters are so clearly marked that since then several other species of the genus have been described by subsequent authors. *D. robusta*, the genotype, is based upon solid, cylindrical stems of about 8 mm diameter, with zooecial apertures circular to oval, averaging 0.1 mm in diameter Mesopores are numerous, circular to angular, separated from the zooecia and each other by thick walls, and forming at regular intervals the aggregations known as maculae. Acanthopores abundant, of two kinds, one set large and developed about one to a zooecium, while much smaller ones more like minute tubules are often abundant but unequally distributed Diaphragms practically absent in both zooecia and mesopores although an occasional one may be noted.

Genotype: *D. robusta* Girty, 1911. Fayetteville shale, vicinity of Fayetteville, Ark. (Figs. 18–20.)

Order CRYPTOSTOMATA (family Rhabdomesontidae Vine, 1883)

Genus Nemataxis Hall, 1886[1]

The discovery of a partly calcified specimen of the genotype at the type locality permitted the preparation of thin sections which indicate that the ramose zoarium, averaging 4 mm in diameter, is composed of thin-walled zooecia arising from a central filiform axis and diverging obliquely toward the surface near which they bend abruptly and develop greatly thickened walls of lamellar tissue pierced by numerous closely spaced acanthopores. Several superior and inferior hemisepta occur in the outer part of the immature region and at the bend to the mature a conspicuous superior one projects into the zooecial cavity. Tangential sections show oval apertures arranged in longitudinal series, separated by thick walls of dense laminated tissue, pierced along their mid-line by small closely spaced granular acanthopores arranged in regular rows. The genus is therefore a well-developed member of the Rhabdomesontidae characterized by the central axis, the occurrence of both superior and inferior hemisepta, and the development of numerous small granular closely spaced acanthopores in rows between the lines of zooecia but not entirely surrounding them.

Genotype: *N. fibrosus* Hall. Devonian (Onondaga): Walpole, Ontario. (Figs. 13, 14.)

Genus Syringoclemis Girty, 1911 (*op. cit.*, p. 206)

The thin sections of the genotype, *S. biserialis* Girty, indicate a hollow cylindrical zoarium of a single layer lined with an epitheca, with mesopores

[1] 5th Ann Rep. State Geol. New York for 1885, expl. pl 25.

and acanthopores of the *Lioclema* type. The vertical section, however, indicates relationships to the Rhabdomesontidae in the boxlike form of the immature region and the sudden bending to the mature zone characteristic of the Cryptostomata. Diaphragms and hemisepta are entirely absent. Tangential sections (Fig. 10) also indicate that the younger zooecial stages have the form characteristic of the Cryptostomata, so the reference to this order seems correct. *Callocladia* has a similar internal structure but possesses either perforated diaphragms or hemisepta. *Syringoclemis* is an interesting genus but more information from the study of additional material is necessary.

Genotype: *S. biserialis* Girty, 1911. Fayetteville shale, vicinity of Fayetteville, Ark. (Figs. 10–12.)

Genus Idioclema Girty, 1911 (*op cit*, p. 210)

This genus described in detail by Dr Girty requires only the illustrations of the internal structure of the genotype to complete its definition The zoarium is of freely branching cylindrical stems of 3 mm diameter, composed of zooecia possessing the family characteristics, namely, occurrence of superior and inferior hemisepta, of large and small acanthopores and absence of diaphragms. The superior hemiseptum occurs at the bend to the mature region and the inferior one below this in the thin-walled immature region. The acanthopores represent the two extremes of growth in these structures as the large ones increase often to the size of an ordinary zooecium and are so numerous as to indent the walls and hide the zooecial outlines, while the small set is represented by minute tubular-like structures perforating the general lamellar tissue. The large acanthopores of the usual cone-in-cone structure show the central tube with especial clearness and are composed of lamellar tissue pierced by dark granular tubules Altogether the genus represents the extreme of the development in the simpler types of the family.

Genotype: *I. insigne* Girty, 1911. Fayetteville shale, vicinity of Fayetteville, Ark. (Figs. 15–17.)

PALEONTOLOGY.—*New Devonian stratigraphic units.*[1]   G. Arthur Cooper, U. S. National Museum.

The following names are proposed so that they will be available for use on the forthcoming "Correlation Chart of Devonian Formations" of the National Research Council. Two names are new, but the others replace preoccupied terms.

Stony Hollow member of Marcellus formation: A conspicuous layer of sandstone ranging from 75 to 100 feet in thickness and consisting chiefly of fine-grained, calcareous sandstone. The type section is located at the bend of New York State Highway 28 and along the railroad opposite the bend at the entrance to the valley leading up to the settlement of Stony Hollow, 1¾ to 2 miles northwest of the bridge over Esopus Creek on the west side of Kingston, N. Y. This member was first encountered on U. S. Highway 209 near Echo Lake, Pa., and on

the same road about 1 mile north of Port Jervis, N. Y. It is to be seen at few places between Port Jervis and Kripplebush, but northeast of that place it forms conspicuous cliffs and ledges on the west side of Esopus Creek to Kingston. Northeast of Kingston it appears as cliffs and ledges from Mount Marion to Leeds and from there to Climax on the Coxsacki Quadrangle. It appears also in Coeymans Hollow and was traced to the falls of Onesquethaw Creek southwest of Albany. Here a few layers of limestone appear in the upper part of the sandstone, which has thinned to 24 feet. West of the Onesquethaw these limestones of the Stony Hollow become the Cherry Valley limestone as exposed in Stony Creek, Schoharie Valley.

Although none of the large Cherry Valley cephalopods has been seen in the Stony Hollow member, other fossils were taken that occur in both the sandstone and the limestone. A species of the trilobite *Dechenella* and a small new species of *Pentamerella* are most abundant in both facies. Besides these a number of other new species occur, among them specimens of the brachiopod *Kayserella*. Absence of the characteristic goniatites is explained by the facies change from black limestone to sandstone. In the Middle and Upper Devonian of New York occurrence of goniatites appears to be controlled by facies, the shells of these animals seldom occurring outside of the black and gray shales.

Identification of the Stony Hollow member as the sandstone equivalent of the Cherry Valley limestone helps to elucidate the section along the Catskill Front. Beds hitherto classified as "Marcellus" shale (Bakoven of Chadwick) immediately underlie the Stony Hollow member and are now proved to be the equivalent of the Union Springs member. The Stony Hollow underlies the Mount Marion formation of Grabau at its type section; consequently the Mount Marion is interpreted as the sandy facies of the Chittenango black shale member overlying the Cherry Valley to the west.

Delphi Station member. Proposed to replace the Delphi shale of Cooper, 1930 (not Brown, 1883, or Gould, 1902). The name is derived from Delphi Station, Cazenovia Quadrangle, N. Y., which is about 1½ miles northwest of Knights Falls, the type section of the member.

Chenango sandstone: To replace the Colgate sandstone of Cooper, 1930 (not Calvert, 1912). The name is derived from the Chenango Valley and the type section is the quarry at the top of the hill just south of the buildings on Colgate University campus and overlooking Chenango Valley to the northwest.

Butternut shale: To replace Berwyn of Cooper, 1930 (not Richards

and Birk, 1925) with the type section in the Cascades formed by a branch of Butternut Creek, southeast of Syracuse, Tully Quadrangle, N. Y.

Little Rock Creek limestone: Proposed for the gray, brittle, conchoidally fracturing limestone above the Logansport limestone on Little Rock Creek above the road-crossing a mile above Lockport, Ind. This formation, 7 feet thick, contains a fauna including a large *Chonetes* called *C. manitobensis, Emanuella subumbona,* and a few other species. The lithology and fauna suggest possible relationship to the Tully limestone of New York.

Plum Brook shale: Proposed to replace Plum Creek shale of Grabau, 1917 (not Foerste, 1905, or Ulrich, 1917). Grabau derived his name from Plum Brook, 2 miles northeast of Prout Station, Sandusky Quadrangle, Ohio, but erroneously recorded the name as Plum Creek. The more accurate designation is therefore substituted.

ZOOLOGY. —*A new Solenocera and notes on the other Atlantic American species.*[1] MILTON J. LINDNER and WILLIAM W. ANDERSON, U. S. Fish and Wildlife Service. (Communicated by WALDO L. SCHMITT.)

During the course of the investigation of the shrimp fishery of the Gulf of Mexico undertaken with the Fish and Wildlife Service ship *Pelican* several species of the genus *Solenocera* were captured including the new species that is herein described. The *Pelican* type and paratype have been deposited with the U. S. National Museum. A key to the Atlantic American members of this genus has been prepared in order to provide a means for ready identification of the various species and to set forth the relationship of the new species with the other American forms.

We take considerable pleasure in naming this new species for Dr. Frank W. Weymouth, professor of physiology, Stanford University, California, in recognition of the invaluable counsel, training, and advice that we have received from him. We wish to acknowledge our indebtedness also to Dr. Waldo L. Schmitt, of the U. S. National Museum, for his kindness in furnishing us with material and for his ready and continued assistance in all matters.

<div align="center">

Solenocera weymouthi, n. sp.   Fig. 1, a–c

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Material examined.—1 ♀, type; *Pelican* station 137-2; 29°28′ N , 87°30′ W , March 1, 1939, trawl 46 fathoms.

1 ♂, paratype; *Pelican* station 137-2; 29°28′ N., 87°30′ W.; March 1, 1939, trawl 46 fathoms.

1 ♂, allotype; U.S.N M no. 119885; Tortugas, August 5, 1932, 190–280 fathoms; boat station 74.

71 ♂ and 78 ♀ paratypes; *Albatross* station 2605; between Cape Hatteras and Cape Lookout, N C.; 32 fathoms; U. S. National Museum.

Description.—Antennular flagella flattened and canaliculate but not so pronouncedly so as in the other six American species Pterygostomian spine absent. Pterygostomian angle produced forward into a blunt flaplike projection. Branchiostegal spine absent. Rostrum rather deep with a convex lower margin, which curves upward to a sharp tip; with a distinct lateral ridge and armed above with 7 to 10, usually 8 or 9, teeth of which three lie behind and one above the orbital margin. Postrostral carina does not extend behind level of cervical sulcus Cervical sulcus deep and well marked, the posterior margin a sharp ridge Cervical sulcus does not cross dorsum of carapace. Orbital angle bears a distinct sharp-pointed tooth or spine Antennal angle produced into a sharp-pointed buttressed spine, which is but little larger than the spine in the orbital angle Postorbital spine large; larger than hepatic, antennal or orbital angle spines and placed about midway between antennal and orbital angle spines.

Ocular peduncle short and stout, eye large Antennular flagella very short, about seven-tenths carapace length in type female, but in the Tortugas male the antennular flagella is about one-fifth longer than carapace Inferior flagellum about twice as broad as superior. Antennular peduncle in type female rather densely coated with pubescence but in smaller specimens this condition is less marked Antennal scale short in most cases, however, in the type female it exceeds the antennular peduncle by about 7 8 per cent of its own length In many of the smaller specimens available the antennular peduncle exceeds the antennal scale When an average was taken of the 130 specimens on which measurements were possible, the antennal scale was found to exceed the antennular peduncle by 1 1 per cent of its own length (length of antennal scale); ranging from −4 6 per cent to +8 5 per cent.

In the type female the third maxilliped extends beyond the antennal scale by about the length of its dactyl Carpus of third periopods slender for their distal half, but on proximal half the leg rapidly thickens and attains approximately the same thickness as the merus. Ischium and basis of first periopods armed on their distal margins with a large sharp spine. Only basis of second periopods armed Third, fourth, and fifth periopods with basis and ischium unarmed

In the type female the coxae of the third, fourth, and fifth periopods are produced medially, those of the third almost uniting, those of the fourth produced less than the third and not nearly meeting, and those of the fifth produced even less than the fourth and widely separated. Median projections of coxae of fourth periopods bear a strong sharp tooth or spine on their proximal margins These spines project mediad over the plate of the thirteenth sternite. Coxae of the fifth periopods bear a small toothlike projection on their anterior margins

In the Tortugas male the coxae of the third periopods do not appear to be produced medially, those of the fourth produced only slightly, and those of the fifth more than the fourth but none so extensively as in the female Anterior margins of coxae of fifth legs bear a large toothlike projection.

Although not well adapted for the open type petasma as encountered in this group we are using Burkenroad's (1936, pp. 61–62) terminology for

designating the various petasmal lobes. We do this rather than substitute
additional terminology in order not to make the literature more ambiguous
than it is at present. Distoventral lobe of mature male subrectangular in
shape and equal to or slightly exceeding the cincinnulated median margin of
the endopod. Distolateral lobe consists of three distinct lobules the proximal
of which can be referred to Burkenroad's lateral lobule of the distolateral
lobe. The two distalmost ones appear to be derived from what Burkenroad
(1939) terms the median lobule in *Solenocera atlantidis*; the proximal of these
we shall designate as the median lobule and the distal most as the distal
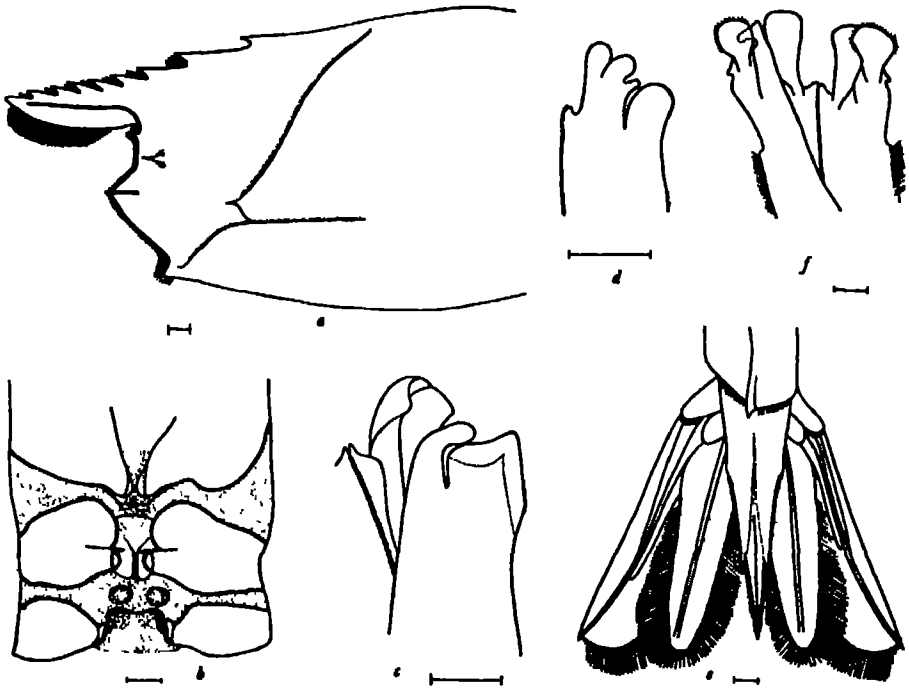
Fig 1 —*Solenocera weymouthi*, n sp . a, Carapace, anterior part, lateral view (type
female), b, thelycum, ventral view (type female), c, petasma, posterior view of distal
part (left endopod) (allotype); d, petasma, immature, posterior view of distal part (left
endopod); e, telson and uropods, dorsal view (type female)   f, *Solenocera necopina*
Burkenroad: Petasma, posterior view of distal portion Scale = 1 mm

lobule In the mature male the lateral lobule of the distolateral lobe is semi-
hook shape and curves over approximately the median half of the distoven-
tral lobe. Median lobule of the distolateral lobe bulbous or knob like and su-
perior to both the lateral lobule and the distoventral lobe. Distal lobule of the
distolateral lobe is superior to the other petasmal structures and folds as a
semi-membranous hood over the median lobule in much the fashion of a sun-
bonnet.
   Paired teeth on anterior part of fourteenth sternite of female, which in all
other species of *Solenocera* from both the Pacific and Atlantic coasts of North
America are very prominent, are in *S. weymouthi* very much reduced in size
and appear as a pair of well separated short blunt protuberances. Bilobed

ridge evident near the center of the fourteenth sternite slightly forward of median projections of coxae of fifth periopods. Plate of thirteenth sternite with a deep well marked longitudinal sulcus down the center. A pair of large blunt projections arise from posterior part of twelfth sternite and project over anterior portion of thirteenth. Entire thelycum pubescent.

Epipodites through the twelfth deeply bifurcated, shorter ramus one-half or more the length of longer ramus. Epipodites of thirteenth somite shallowly bifurcated.

In the type female the first and second pleonic terga are uncarinated; posterior two-thirds of the third carinated, the fourth, fifth, and sixth with a high sharp carina. On smaller specimens carina of third pleonic tergite is less pronounced or not evident, apparently this varies with age. Posterodorsal and posteroventral angles of sixth pleonic tergite ending in a spine.

Telson long terminating in a sharp point; bears a large pair of fixed lateral spines; anterior half of dorsal surface with a median sulcus bordered by two ridges which terminate in the lateral spines; posterior half bears a distinct median carina which extends nearly to the sharp tip.

Uropodal endopods slightly exceed tip of telson and exopods of uropod exceed endopods by approximately the same distance that endopods exceed telson Externodistal margins of uropodal exopods armed with a tooth or spine.

Measurements.—S *weymouthi,* like *S. atlantidis* and *S. necopina,* appears to be a comparatively small species of shrimp not attaining a size much larger than the type female with carapace length of 17.5 mm. *S. vioscai,* on the other hand, reaches a size much larger A majority of the specimens of *S weymouthi* from the North Carolina coast, with carapace lengths ranging from 4 2 to 8 4 mm, which comprises the bulk of available material, was immature. In the males the petasmal endopods were not united, and the lobes were poorly developed in most cases. The male from Tortugas with carapace length of 10 3 mm was mature with the endopods united and the lobes well developed.

Distribution —As at present known *S. weymouthi* occurs from North Carolina to Alabama

Remarks.—So far as known *S. weymouthi* differs from all other members of the genus with the exception of *S. melantho* De Man and *S. steindachneri* (Balss) in its possession of a tooth or spine on the externodistal margin of the exopod of the uropod (Burkenroad, 1936, pp. 105, 121).

S weymouthi is further distinct from *S. agassizii* Faxon, *S. membranacea* (Risso), *S m. africanus* Stebbing, *S comatus* Stebbing, *S novae-zealandi* Borradaile, *S. vioscai* Burkenroad, *S atlantidis* Burkenroad, *S. necopina* Burkenroad, *S. florea* Burkenroad, *S. mutator* Burkenroad, *S faxoni* De Man, *S distincta* De Haan, *S. (Parasolenocera) annectans* Wood-Mason, and possibly *S crassicornis* H Milne-Edwards (1837) in that it possesses neither a pterygostomian nor a branchiostegal spine *S weymouthi* further differs from *S. crassicornis* in its possession of a pair of fixed lateral spines on the telson; these spines are reported as absent in *S. crassicornis* (Burkenroad, 1934, p 72).

From those members of the genus that like *S. weymouthi* possess neither pterygostomian nor branchiostegal spines, *S weymouthi* in addition to the possession of a spine on the externodistal margin of the exopod of the uropod (except *S. melantho* and *S. steindachneri*) differs as follows:

In *S. hextii* Wood-Mason the postrostral carina extends to the posterior

margin of the carapace whereas in *S. weymouthi* the postrostral carina does not continue beyond the level of the cervical sulcus. In the males of *S. hextii* the cincinnulated median margin of the petasma extends beyond the distoventral lobe whereas in *S. weymouthi* the cincinnulated median margin of the petasma falls at about the level of the distoventral lobe. In *S. hextii* the pair of knobs on the fourteenth sternite of the female are placed together whereas in *S. weymouthi* they are well separated. *S. hextii* has a spine on the cervical carina dorsad the hepatic spine which is not present in *S. weymouthi*.

In *S. koelbeli* De Man the postrostral carina extends to the posterior margin of the carapace whereas in *S weymouthi* the postrostral carina does not cross the level of the cervical sulcus In *S. koelbeli* the cervical sulcus makes a notch in the dorsal carina of the carapace whereas in *S. weymouthi* there is no notch in the dorsal carina.

S. rathbuni Ramadan has no spine at the orbital angle whereas *S. weymouthi* has a large sharp spine at the orbital angle. In *S. rathbuni* the epipodites through the thirteenth are deeply bifurcated whereas in *S weymouthi* the epipodites through the twelfth are deeply bifurcated with the thirteenth only shallowly bifurcated.

S. pectinatus (Bate) does not have the orbital angle armed whereas *S. weymouthi* has a large sharp spine at the orbital angle. The petasma of *S. pectinatus* has a series of large comblike spines on the outer surfaces of the distolateral lobes which are not present in *S. weymouthi* The petasma of *S. pectinatus* is cincinnulated along its median margin much higher than occurs in *S. weymouthi* and differs widely from it in structure

S. melantho De Man has a well-defined postrostral carina extending nearly to the posterior margin of the carapace whereas in *S. weymouthi* the postrostral carina does not cross the level of the cervical groove. The paired knobs on the fourteenth sternite of the thelycum are placed together whereas in *S. weymouthi* they are well separated The cincinnulated median margin of the petasma extends much higher in *S melantho* than in *S weymouthi*

In *S. steindachneri* (Balss) the cincinnulated median margin of the petasma extends considerably beyond that in *S. weymouthi*. Furthermore Balss figures a dorsal carapacic spine posterior to the cervical groove. This is lacking in *S weymouthi*.

The cincinnulated median margin of the petasma of *S weymouthi* appears to resemble more closely those *Solenocera* possessing branchiostegal or pterygostomian spines than those lacking these spines.

S. weymouthi like other species of the genus from the Atlantic coast of the United States is variable in the matter of the antennal scale exceeding the antennular peduncle, varying from the antennular peduncle exceeding the antennal scale to the scale exceeding the peduncle by 8 5 per cent of its own length. In *S atlantidis* measurements on 17 specimens from the United States National Museum show that the antennal scale varies from shorter than the antennular peduncle to exceeding it by about 7 per cent of its own length with an average of 1.3 per cent longer. *S. vioscai* agrees very closely in this character (Burkenroad, 1939, p. 15) with *S weymouthi* and *S atlantidis*. *S. necopina*, on the other hand, has a longer antennal scale than the other three Atlantic American species. Measurements on 18 specimens of *S. necopina* from the United States National Museum reveal that the antennal scale exceeds the antennular peduncle from over 13 per cent to 24 per cent its own length with an average of 17 per cent longer Therefore, this character can be used to separate *S. necopina* from the three other species under consideration.

Solenocera necopina Burkenroad   Fig. 1, f

Solenocera vioscai Burkenroad, 1936, p. 122.
Solenocera necopina Burkenroad, 1939, p. 7.

Material.—9 ♂ and 10 ♀ and several broken shrimps; U S.N.M no. 9767; *Albatross* station 2402; Gulf of Mexico.

Burkenroad, 1939, described this species of *Solenocera* from a single sub-adult female taken at the edge of the Continental Shelf in the Northern Gulf of Mexico in 125 fathoms of water There were found in the United States National Museum 19 whole and several broken shrimp that were determined as this species As Burkenroad was unable to give an account of the male petasma there follows a description of this organ.

Median margin of petasma similar to *S. vioscai* Burkenroad in that it is cincinnulated for about two-thirds the length of the petasma and falls considerably below distolateral and distoventral lobes. Distoventral lobe provided with a rounded projection margined with spines. Distolateral lobe divided into two lobules. Lateral lobule slightly shorter than median lobule and distoventral projection; possessing a slender lateral projection which in posterior view is hidden behind projection of distoventral lobe Median lobule of distolateral lobe broad, subrectangular or club shaped, slightly exceeding lateral lobule and about equal to spinous distoventral projection.

Females in the United States National Museum collection agree with Burkenroad's description of the thelycum except that the sculpture is much more pronounced and the teeth and ridges are more developed in the mature specimens

Males in the series of specimens ranged from a carapace length of 9.8 to 13 1 mm and the females from 11 4 to 18.4 mm all of which appear mature. The largest specimen in the collection, a female, had its carapace so badly crushed as to make accurate measurements impossible

The orbital angle was described as marked but not acute or produced. In the larger specimens the orbital angle while not sharp or spinelike is definitely produced.

Burkenroad's statement (1939, p. 7) that the postrostral carina does not extend behind the level of the cervical sulcus is erroneous for large specimens as in these there is a definite low carina extending nearly to the posterior margin of the carapace Burkenroad (*loc cit*) states that the first through the third pleonic terga are uncarinated Here again we find that in large specimens the third pleonic tergite is carinated on its dorsal surface for approximately the posterior two-thirds of its length.

Burkenroad's figure of *S necopina* does not show a spine or tooth on the posterioventral edge of the sixth pleonic tergite Our specimens have a spine at this point which compares in size and position to a similar spine in *S. atlantidis*

In large specimens of *S atlantidis* the postrostral carina does not extend beyond the cervical sulcus as stated by Burkenroad (*loc. cit*), but we find that in these same specimens the third pleonic tergite is partially carinate. This carination is not evident in the smaller specimens.

The pterygostomian spine in *S. necopina* is much stronger and possesses a wider base than does this structure in similar sided specimens of *S. atlantidis*.

KEY TO ATLANTIC AMERICAN SOLENOCERA

A. Pterygostomian spine present. No spine on externodistal margin of uropodal exopod.

   B. Epipodites X through XIII strongly bifurcate, shorter ramus at least
     half the length of undivided portion excluding peduncle. Pacific
     American species.
             agassizii Faxon, *mutator* Burkenroad, *florea* Burkenroad
BB. Epipodites X through XIII only slightly furcate, shorter ramus not
     more than one-third the length of undivided portion excluding
     peduncle.   Atlantic American species.
    C. Rostral teeth 8 to 10, usually 9. Postrostral carina high and sharp,
      deeply notched at level of cervical groove   .   *vioscai* Burkenroad
   CC. Rostral teeth 5 to 7, usually 6. Postrostral carina low or absent,
      only slightly depressed at level of cervical groove.
     D. Antennal scale long, exceeding antennular peduncle by at least
       13 per cent its own length. No well defined tooth at orbital angle
       Pterygostomian spine large with wide base, joining carapace in
       a gentle curve   *necopina* Burkenroad
    DD Antennal scale short, less than antennular peduncle to exceed-
      ing antennular peduncle by about 8 per cent of its own length
      A well defined tooth at orbital angle. Pterygostomian spine
      small with narrow base, joining carapace at approximately a
      right angle   *atlantidis* Burkenroad
AA Pterygostomian spine absent. Spine on externodistal margin of uropodal
   exopod..   *weymouthi*, n. sp.

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ZOOLOGY.—*New genera and species of millipeds from the southern peninsula of Haiti.*[1]   H. F. LOOMIS, U. S. Bureau of Plant Industry.

The western end of the southern peninsula of Haiti is an area from which no millipeds ever have been reported. Indeed, this might be said for the entire western half of the peninsula, with the single exception of the high mountain Morne La Hotte, from whose slopes Dr. P. J. Darlington, of the Museum of Comparative Zoology, collected 12 species of millipeds in 1934. Ten of these species proved to be new.[2]

It is only within the last two or three years that an all-weather road leading from Aux Cayes to Jeremie and thence to Anse d'Hainault has given ready access to the interior country hitherto reached only on horseback or afoot from the coastal towns. This road traverses areas having great scientific interest to naturalists, as they contain plants and animals not found elsewhere in Haiti, many of them probably undescribed. A 3-day visit through this country by automobile in the summer of 1940 afforded the writer several opportunities incidental to the object of the trip, to search the humus layer for members of the diplopod fauna. These brief stops, however, resulted in a collection of nine species of millipeds, four of which were new to science, three representing undescribed genera. Two of these genera are of families not previously known from Haiti; in fact, one of them has not before been found in the West Indies, its closest relatives being in California. A new species of *Rhinocricus*, of large size and handsome coloring, was called to my attention by T. A. Fennell, Agricultural Adviser to Haiti, who saw it several weeks prior to the writer's visit while in company with Andre Audant, of the Haitian Department of Agriculture, who warned that the animal had the startling ability of projecting its caustic repugnatorial fluid far from the body and hence was a dangerous creature to handle. In addition to these new forms, a fifth species, previously described, is recorded from Haiti for the first time.

The type specimens of the new species here described are deposited in the U. S. National Museum. Paratype specimens are in the Museum of Comparative Zoology, Cambridge, Mass.

Family SIPHONOPHORIDAE

Siphonophora sp.

Five or six females, not definitely assignable to species from between Chambellan and Dame Marie, August 1, 1940.

Family STEMMIULIDAE
Prostemmiulus sp.

A female, the species not identifiable, from between Chambellan and Dame Marie, August 1, 1940.

Family CAMBALOPSIDAE
Cambalomma, n. gen.

Type.—*Cambalomma laevis*, n. sp.

Diagnosis.—The smooth, *Spirostreplus*-like body has the surface of the segments continuous instead of divided into two parts by a transverse constriction; hence, the segments more nearly resemble those of the order Anocheta, but in this respect *Cambalomma* is no more anomalous in the present family than is the genus *Choctella* Chamberlin in the Cambalidae. In other characters *Cambalomma* falls readily into the Cambalopsidae.

Description.—Body of moderate size and rather slender, from 15 to 17 times as long as broad and scarcely constricted behind the first segment, without longitudinal crests or swellings; surface finely shagreened, dully shining.

Head with eyes very well developed and widely separated, composed of numerous ocelli in four series, vertex faintly sulcate at middle; clypeus with two setiferous punctures on each side; labrum with about nine setiferous puntures on each side; antennae slenderly clavate, with a sensory patch of tiny setae at the outer distal end of joints 5 and 6; gnathochilarium with the mentum constricted above the basal half but not transversely divided.

First segment with the sides broadly rounded and clasping the sides of the body; a raised rim proceeding from behind the eye around the lateral limits to the posterior margin.

Ensuing segments with surface continuous, unbroken by a transverse sulcus or constriction dividing each segment into two parts as in other genera; the anterior portion of each segment, that usually covered by the preceding segment, with tiny, fine, undulating, transverse striae, remainder of segment very finely roughened and dully shining; ventral striae pronounced, extending over the posterior half of each segment less than halfway to the pores on the anterior segments and even more restricted on the segments thereafter; pores easily seen, beginning on segment 5 and apparently ending on the antepenultimate segment as no pore is visible on the somewhat telescoped penultimate segment.

Last segment only slightly produced, much exceeded by the inflated anal valves, which meet in a deep groove, preanal scale a narrow ellipse with a pad process at each side projecting from under the margin of the last segment.

Gonopods relatively simple, somewhat resembling those of the genus *Epinannolene* but possibly not fully developed as the last two segments of the largest and oldest male (type) are legless, indicating that the animal lacks one molt of maturity.

First pair of male legs 5-jointed, the coxae with a long process at the base of each on the posterior side, the process projecting downward into a special excavation of the sternum; other male legs normal.

Cambalomma laevis, n. sp.

One male (type) with 61 segments, the last two of which are legless, and five immature females from Jeremie; one mature female from between Chambellan and Dame Marie, August 1, 1940.

Description.—Length of mature female 60 mm, diameter 4 mm; number of segments 62; body very slightly constricted at segments 3 and 4, thereafter with the sides parallel to the posterior fourth from which it narrows gradually; surface of body dully shining but with the head, first segment and the anal segment more brilliantly shining.

Head with antennae slenderly clavate (Fig. 1); joints 2 and 3 thinner and slightly longer than the others, joints 5 and 6 widest and each with a sensory spot of setae at the distal end on the outer side; eyes elongate oval, separated from each other by about twice their longest diameter, composed of 28 to 30 ocelli in four rows with the longest row behind, the rows containing ocelli as follows: 9, 8, 6, 5 or 8, 9, 7, 6; gnathochilarium as shown in Fig. 2

First segment broadly and evenly rounded on the sides (Fig 3) and clasping the body; the raised rim extending from behind the eye to the posterior margin, sometimes with two or three tiny rudimentary striae inside it below.

Ensuing segments as described for the genus.

Last segment not much produced, the apex broadly rounded and much exceeded by the inflated and brilliantly shining anal valves, which meet in a deep groove

Legs with the sterna finely roughened like the dorsal surface of the segments and without striae

Gonopods as shown in Figs. 4 and 5.

Seventh segment of the male deeply emarginate in front ventrally to receive the tips of the gonopods, the surface behind the emargination specially elevated.

First pair of male legs as shown in Figs 6 and 7.

Family SPIROBOLIDAE

Rhinocricus modestior Chamberlin

Two specimens from between Camp Perrin and Rivière Glace, July 31, 1940. Other specimens from between Chambellan and Dame Marie, August 1, 1940.

Rhinocricus latespargor, n. sp.

One male (type) and four females from between Camp Perrin and Rivière Glace, July 31, 1940. Collected by T A. Fennell and H. F. Loomis but first seen several weeks previously by T. A. Fennell.

Diagnosis.—This species may be recognized instantly by its size and striking black and yellow coloration, a combination found in no other West Indian member of the genus

Description.—Length of the type 145 mm, width 11.5 mm, females to 159 mm long and 14 mm wide; number of segments 53 to 55; color of living ani-

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Figs. 1–7.—*Cambalomma laevis*, n sp 1, Antenna; 2, gnathochilarium; 3, first segment and part of head, lateral view; 4, right gonopod with median plate, anterior view; 5, right gonopod, posterior view; 6, first leg and sternal plate of male, anterior view; 7, first leg and sternal plate of male, posterior view.

Figs. 8, 9.—*Rhinocricus latespargor*, n. sp . 8, Gonopods, anterior view; 9, inner gonopod, anterior view

Figs 10–12 —*Proaspis aitia*, n sp. 10, Head and first two segments, dorsal view; 11, lateral carinae of segments 10 and 11, dorsal view, 12, segments 19 and 20, anal valves and preanal scale, ventral view.

Figs 13–17.—*Fennellia onipes*, n sp · 13, Right hand half of segments 5, 6, and 7, oblique lateral view; 14, segments 18, 19, and 20, dorsal view; 15, gonopods in normal position inclosing inner joints; 16, right hand gonopod extended, vertical ventral view; 17, gonopod extended, oblique outer view
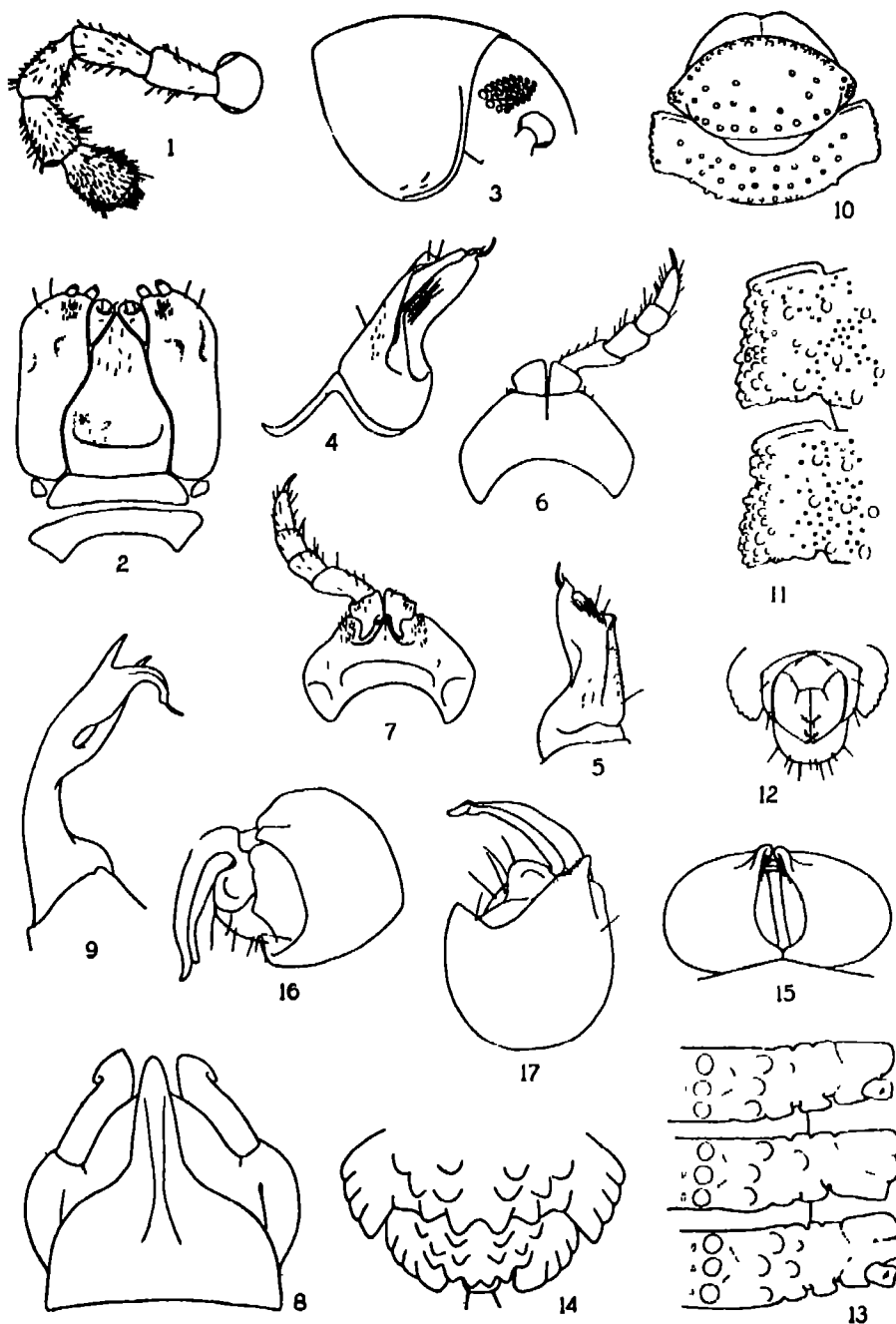
Figs. 1–17 —(See opposite page for explanation)

mals brilliant shining black with the narrow margin of each segment, the posterior third of the hindbelt, bright lemon-yellow; first segment completely surrounded by a narrow band of yellow; last segment yellow at apex.

Head with the median line moderately impressed on the vertex, very deeply impressed on the clypeus immediately above the center tooth of the labrum; transverse lines of the frontal area faintly impressed; margin of head below the eye with a broadly raised rim; antennae with numerous sense cones; joint 2 longest; eyes composed of 33 to 41 ocelli in six, rarely seven, rows paralleling the margin of the first segment.

First segment with lateral limits sharply rounded, almost angular, the raised rim short and not well developed, beginning far below the eye and reaching to the back margin without following the curve of the lateral margin.

Second segment with a quite prominent shoulder below the limits of segment 1, its ventral surface slightly concave and coarsely striate.

Ensuing segments have the forebelt impressed with fine, short, undulating lines; midbelt very smooth and shining; hindbelt much the same but with a few tiny punctures; transverse sulcus indicated by a faintly impressed line only on the sides of the body; lateral sulcus also faintly impressed; pores quite large and placed as in *R. lethifer* Loomis; scobinae small, deep and close together, beginning on segment 10 and usually visible to segment 23.

Last segment with the tip slightly exceeding the anal valves, the apex finely punctate, at base more or less wrinkled transversely.

Anal valves much like those of *R. lethifer* but the punctations more scattered; preanal scale shorter and more elliptical than in that species, the apex more broadly rounded with the sides not emarginate.

Gonopods as shown in Figs. 8 and 9

Seventh segment of the male with an elevated ventral crest directed somewhat backward and broadly but shallowly emarginate at the middle in front, the face of the emargination and the median part of the crest smooth, the crest striate elsewhere.

Anterior male legs with coxal modifications much like those of *R. lethifer*, the outer joints similarly without ventral pads.

Remarks —As in the case of the larger *R. lethifer*, discovered in 1927 near the middle of the southern peninsula, this milliped also has the ability of ejecting its repugnatorial fluid far from the sides of the body and is, accordingly, to be classed as an animal dangerous to man as well as to smaller creatures that might incite it to discharge its poison toward them Likewise, as with *R. lethifer*, this characteristic is recognized by the natives of the region for *R. latespargor* as Mr Fennell, who first saw the millipeds and told me of them, was admonished by his Haitian companion to handle them with care as roughness might induce the discharge. Those collected on my visit were taken alive in a large humus-filled can to the house where we were to pass the night. There, on the cement floor of the porch, the animals were released and, as they began to walk away, were irritated with a long switch until the repugnatorial fluid was ejected, when the distance attained by it was measured and recorded Several of the millipeds ejected the fluid distances up to 24 inches from each side of the body but the maximum effort was a double salvo, which sent the discharge 28 inches on one side and 33

inches on the other side of the animal! This same animal had twice, immediately before this maximum effort, ejected fluid distances under 24 inches from the body, although in both these instances less fluid had been used than in the third ejection. The fluid, greenish yellow in color, left the body so suddenly and in such short, fine jets that it scarcely could be seen until it fell on the cement floor in tiny droplets distributed somewhat fanwise far from the body.

Azygobolus tumidus Loomis

One mature male was found in a fruit cluster of the palm, *Bornoa crassis-patha* (Martius), collected between Cavaillon and Aux Cayes, July 31, 1940. This is the first record of this milliped in Haiti.

Family PLATYRHACIDAE

Although this family is well represented in Central and South America only one species previously has been known in the West Indies, *Nanorrhacus luciae* (Pocock), from the island of St. Lucia A Cuban species, which C. H Bollman in 1888 included in this family under the name *Stenonia maculata*, has recently been shown to belong in the Chytodesmidae and was made the type of the genus *Schizodira* [*] With the discovery in Haiti of a new species of platyrhacid having a combination of characters not found in other American forms the necessity arises of erecting a genus to receive it.

Proaspis, n. gen.

Type.—Proaspis ailia, n. sp.

Diagnosis.—Apparently differing from all other American members of the family in the peculiar construction of the preanal scale, which is elevated in front and projects forward a little, overlapping the posterior margin of segment 20, a condition to which the generic name alludes. In a combination of other characters *Proaspis* differs from previously known American genera also.

Description —Body of intermediate size, approximately 40 mm long and less than one-sixth as wide; dorsum only moderately convex, with lateral carinae above the middle of the body and projecting a considerable distance away from it.

Head with median depression of the vertex rather wide and deep; labrum concave, smooth and shining in contrast to the granular surface elsewhere.

First segment wider than the head but narrower than the second segment; lenticular in outline; a series of large tubercles along the front and back margins, a few scattered ones in the median area and a small concentration at each lateral angle; surface between the large tubercles covered with small round granules.

Ensuing segments with three transverse rows of large tubercles, the remainder of the surface with numerous smaller tubercles or granules as on segment 1 but lacking any semblance of polygonal areas or impressed lines; lateral carinae with a prominent shoulder at base in front, the outer margin thickened, especially on the poriferous segments, and with numerous rounded or oliviform tubercles, some of which are almost as large as the tubercles of the dorsal rows; pores opening obliquely outward from the margin on all except the last few segments where they are more nearly dorsal; an-

[*] Psyche **48**: 35-39 1941.

terior subsegments densely beset with tiny elongate granules; segment 19 with the lateral carinae produced backward, the posterior limits almost acute; last segment much exceeding segment 19, the posterior margin broadly rounded; dorsal surface granular, lacking large tubercles but it and the margin with definitely placed setae.

Preanal scale slightly elevated in front and a little produced forward, covering the median portion of the ventral margin of segment 20.

Sterna without processes at the base of each leg; surface finely granular.

Segment 3 of the females with the ventral anterior margin emarginate on each side of the middle, the margin behind the excavations strongly raised and thickened, especially that between the two emarginations.

Proaspis aitia, n sp.

Three females, one the type, collected from beneath loose grass at roadside between Camp Perrin and Rivière Glace, July 31, 1940.

Description.—Length 38 mm, width 6 mm; color dull yellowish white but with an incrustation of reddish-brown, claylike material almost obliterating the body color

Head and first two segments as shown in Fig 10; antennae resting in a slight depression laterad of the socket, the depression not sharply limited above or below; distance from each socket to the side of the head equivalent to the distance between the antennae.

Dorsum of segments moderately convex, the lateral carinae projecting almost horizontally from above the middle of the body, their shape and the sculpturing of the body as shown in Fig. 11; posterior end of the body narrowing gradually, beginning with segment 17.

Last segment much prolonged beyond segment 19 and with the posterior end very broadly rounded; dorsal surface granular but lacking large tubercles as on preceding segments, there are, however, two large subterminal dorsal setae with six similar setae projecting from the apical margin and from two to four small setae beneath the apex; below the apical projection and near the margin on each side are two large setae.

Preanal scale, anal valves, and the last two segments are shown in ventral view in Fig. 12.

Family CHYTODESMIDAE

Docodesmus parvior Chamberlin

A male collected at Jeremie and a female collected between Chambellan and Dame Marie, August 1, 1940.

Family STIODESMIDAE

Fennellia, n. gen.

Type   Fennellia ovipes, n sp

Diagnosis —With the same pore formula as *Psochodesmus* Cook but the body larger and definitely broader, having lateral carinae more extensive and obliquely descending nearly to the level of the legs instead of projecting almost horizontally high on the sides of the body.

Description —Body with 20 segments, broad, in outline much as in *Docodesmus* Cook, only four or five times longer than its width and less than 10 mm long; the dorsum strongly arched with the lateral carinae descending at an oblique angle almost to the level of the sternal plates.

Head broad, extending far outward from the antennal sockets; vertex

scarcely elevated, strongly erose and granular, medianly channeled; frontal area transversely rugose; clypeal area smooth and shining.

First segment with the thin expanded front margin much as in *Docodesmus* but with 10 instead of 12 scalloped quadrate areas along it; surface with two transverse rows of large tubercles, six in the anterior row, four in the one behind, the surface elsewhere finely granular except the expanded margin, which is almost smooth.

Ensuing segments with four oblique, ascending, longitudinal rows of large tubercles, three tubercles in each row; laterad of each outer row from one to three slightly smaller tubercles usually are present; remainder of dorsal surface of segments dull but not definitely granular, under surface of body finely and evenly reticulated; posterior margin of segments with a prominent lobe at the base of each lateral carina; lateral carinae thin, obliquely descending to near the level of the sterna, the outer margin also oblique with the anterior corner lower than the posterior one; pores opening from large quadrangular processes on segments 5, 7, 9, 10, 12, 13, and 15; carinae of segments 2, 3, 4, 6, 8, 11, and 14 with three outer scallops; segments 16 to 19 inclusive with four outer scallops; segment 5 with a single scallop or lobe in front of the pore callus; other poriferous carinae with two scallops in front of the pore callus

Last segment small but visible from above between the two short backwardly produced lobes of segment 19; preanal scale triangular.

Gonopods each with a very large hemispherical basal joint capable of wholly containing the outer joint, the two basal joints usually closely applied to each other mesially, almost completely hiding the terminal joints within

Third segment of the female with a low crescentic ventral ridge behind the genital opening between segments 2 and 3

This genus is named for T. A. Fennell, my friend and companion on the journey to the southern peninsula of Haiti

Fennellia ovipes, n sp.

Two males, one the type, and two females from Jeremie, August 1, 1940.

Description —Body from 8 5 to 9 mm long and from 1 8 to 2 mm wide; color rather dark dull brown, the large pore calluses colorless in sharp contrast to the rest of the dorsal surface; head with the roughened vertex almost black, the remainder of the head, the antennae, legs, and ventral surfaces colorless.

Body arch high with lateral carinae obliquely descending a considerable distance from the sides of the body as shown in Fig 13, which also shows the sculpturing of the dorsum and the margins of the segments as well as the shape and position of the pore calluses; posterior end of the body shown in Fig. 14; the last segment has two dorsal tubercles in front which are not visible in the figure, being hidden by the penultimate segment; preanal scale of moderate size, triangular; anal valves flattened, with an indefinite ridgelike swelling down the middle of each; margins rather thin but strongly elevated

Gonopods as shown in Figs 15, 16, and 17.

The females have the thin, flattened genital organs protruding from between the second and third segments and directed forward, almost covering the coxal joints of the second legs.

ICHTHYOLOGY.—*The flatfish* Cyclopsetta chittendeni *Bean from Texas, a new record for the fauna of North America.*[1] EARL D. REID, U. S. National Museum. (Communicated by LEONARD P. SCHULTZ.)

A collection of marine and fresh-water fishes from the vicinity of Galveston, Tex., presented to the United States National Museum by J. L. Baughman, of Houston, contained two examples of the rare flounder *Cyclopsetta chittendeni* B. A. Bean[2] collected by the donor on August 11, 1940, near Galveston. Heretofore this species was known only from five specimens from the vicinity of the Island of Trinidad. The Galveston specimens are much smaller than those from Trinidad, being 83 and 91 mm respectively, in standard length. The type, U.S.N.M. no. 44100, is 172 mm while the remaining four examples are 205 to 230 mm in total length, according to J. R. Norman.[3]

The following counts were made: Dorsal rays, 87 and 89; anal rays, 66 and 69; pectoral 15, lateral line 78 and 80; gill rakers 4+8 on first gill arch.

ENTOMOLOGY.—*A revision of the parasitic wasps of the genus* Necremnus *Thomson (Eulophidae; Hymenoptera).*[4] A. B. GAHAN, U. S. Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

The genus *Necremnus* contains some species that are parasitic upon insects of economic importance. Eight species, of which four are believed to be new, are treated in the accompanying key.

Family EULOPHIDAE
Genus **Necremnus** Thomson

This genus was said by Thomson to have only one spur on the hind tibia, and Ashmead, in his *Classification of the chalcid-flies* (Mem Carnegie Mus 1: 358. 1904), placed it in the tribe Hemiptarsenini, which he distinguished from the tribe Eulophini on the basis of this character The genotype species, *leucarthros* (Nees), however, has two tibial spurs (one very short and difficult to distinguish), and in the other species two very unequal spurs are discernible on all specimens in which the hind tibiae are in proper position for observation.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 25, 1941

[2] Proc U S. Nat Mus 17: 635–636, fig 3 1895

[3] *A systematic monograph of the flatfishes (Heterosomata)* 1: 136–137, fig. 89. British Museum, London, 1934

[4] Received February 25, 1941.

Antenna inserted well below middle of head, not compressed; 9-jointed in the female (scape, pedicel, one distinct ring joint, 3-jointed funicle, and 3-jointed club), apparently 8-jointed in the male (scape, pedicel, apparently without a ring joint, funicle 4-jointed, and club 2-jointed, the first three funicular joints usually each with a branch, or, if unbranched, the scape much enlarged); pronotum short, conical; mesoscutum without parapsidal grooves; scutellum with two pairs of strong setae and without either longitudinal grooves or a transverse furrow; propodeum usually with a median carina but without distinct lateral folds and without well defined spiracular sulci, the spiracles located close to base of propodeum Wings well developed; submarginal vein not broken, marginal vein shorter than submarginal and two or more times as long as stigmal vein; postmarginal vein at least as long as stigmal, usually distinctly longer. Abdomen subsessile, more or less ovate in outline, only the apex of ovipositor visible.

<center>KEY TO THE SPECIES OF NECREMNUS</center>

1. Funicular joints without rami, scape never much enlarged Females   2
   Funicular joints 1 to 3 each with a distinct ramus, or, if without rami, then scape greatly enlarged. Males   9
2. Forewing distinctly marked with fuscous   3
   Forewing without fuscous markings   5
3. Forewing with a large fuscous cloud across middle enclosing a hyaline area adjacent to marginal vein and with three fuscous spots near apical margin; second funicular joint testaceous, rest of flagellum blackish   *maculatipennis* Ashmead
   Infuscation of forewing not as above; second funicular joint concolorous with rest of flagellum.   4
4. Forewing with a large fuscous cloud embracing whole area behind marginal vein; first funicular joint and pedicel subequal
   . .   *californicus* (Girault)
   Forewing with a narrow fuscous spot or incomplete transverse band from stigmal vein and a less distinct fuscous band behind base of marginal vein; first funicular joint nearly twice as long as pedicel
   .   *complus*, n. sp.
5. Bright metallic green   6
   Dark or blackish green, mesoscutum and scutellum sometimes with a coppery tinge.   7
6. Propodeum very weakly sculptured medially and usually with at least slight traces of lateral folds behind middle.   *breviramulus*, n. sp.
   Propodeum distinctly though delicately sculptured medially as well as elsewhere and without traces of lateral folds.   *oregonensis*, n. sp.
7. Postmarginal vein not longer than stigmal vein   *punctifrons* Thomson
   Postmarginal vein distinctly longer than stigmal vein   .8
8. Abdomen about twice as long as broad; marginal vein fuscous or brownish testaceous   *leucarthros* (Nees)
   Abdomen about one and one-half times as long as broad; marginal vein pale yellowish   .   .   *duplicatus*, n. sp.
9. Funicular joints without rami; scape greatly enlarged; second funicular joint testaceous, rest of flagellum blackish; wings maculated with fuscous .   .   *maculatipennis* Ashmead

Funicular joints 1 to 3 with distinct rami; scape usually only slightly broadened; second joint of funicle not differently colored from the others; wings hyaline . . 10
10. Rami of funicular joints short, not more than three times as long as the segments from which they originate and never extending nearly to apex of club. . . . 11
Rami of funicular joints long, four or more times as long as the segments from which they originate and all extending to apex of club or nearly so . . . 12
11. Rami of funicle very short, not twice as long as supporting segments and much less than half as long as flagellum *breviramulus*, n. sp.
Rami of funicle about two and one-half to three times as long as supporting segments, the longest approximately half as long as flagellum.
oregonensis, n. sp.
12. Rami of funicle slender, cylindrical, and clothed with long, slender hairs 13
Rami of funicle more or less compressed, nearly as thick as funicular joints, and without long slender hairs, but rather densely clothed with short coarse and more or less recumbent hairs *leucarthros* (Nees)
13. Postmarginal vein not longer than stigmal *punctifrons* Thomson
Postmarginal vein distinctly longer than stigmal . . *duplicatus*, n. sp.

Necremnus maculatipennis Ashmead

Necremnus maculatipennis Ashmead, Fauna Hawaiiensis 1:331. 1901

This species, described from Hawaii, is represented in the U. S. National Museum by the male and female types The male differs from typical *Necremnus* by having the antennal scape greatly enlarged and compressed and the joints of the funicle entirely without rami The female appears to be typical of the genus and the male differs in no way, except in the antennae.

In both sexes the front wing has a large fuscous cloud in the disk enclosing a hyaline area adjacent to the marginal vein, and there are also three fuscous spots near the apical margin. The second funicular joint is testaceous, the rest of the flagellum black.

Necremnus californicus (Girault), n. comb.

Eulophus californicus Girault, Proc. U. S. Nat Mus 53:446. 1917.

The type of this species lacks the head, abdomen, and wings. The head and wings are mounted on a slide, the head crushed beneath the cover glass.

It may be distinguished from the other species treated herein by the large discoidal cloud covering the whole width of the wing behind the marginal vein. The scape is cylindrical, the pedicel more than twice as long as broad. The single ring joint is about half as long as broad. The first funicular joint is very slightly longer than the pedicel and about twice as long as broad at apex, the second joint a little longer than broad and the third subquadrate. The club is a little longer than the two preceding joints combined and very slightly broader than the last funicular joint. The propodeum is practically smooth, the median carina barely indicated, and the lateral folds and spiracular sulci are entirely absent.

Necremnus comptus, n. sp.

The bimaculate forewing, relatively long and pointed abdomen, and the mostly yellow hind tibia will distinguish this species from all others known to

Female.—Length 2.6 mm. Head as broad as thorax and nearly uniformly strongly reticulate-punctate; ocelli in a low triangle; lateral ocellus about twice its own diameter from eye margin; eyes with short pile; antennae inserted very slightly below a line connecting lower extremities of eyes, 9-jointed; scape subcylindrical, reaching to front ocellus, about five times as long as broad; pedicel about twice as long as broad; ring joint transverse; first funicular joint nearly twice as long as pedicel and about two and one-half times as long as broad; second and third funicular joints equal and each about twice as long as broad; club distinctly 3-jointed, no thicker than funicle, about equal in length to two preceding joints combined, the basal joint longer than broad, second joint subquadrate, apical joint conical, a little shorter than penultimate and terminating in a short spine. Thorax strongly reticulate punctate, the punctures on scutellum and axillae a little finer than those on mesoscutum; prepectus more coarsely sculptured than rest of pleuron; postscutellum about as long as propodeum and sculptured like scutellum; propodeum with very distinct and nearly uniform, fine, reticulate-punctate sculpture, with a distinct median carina and with traces of both lateral folds and spiracular sulci but these not distinctly impressed Forewing extending about to apex of abdomen, its length to breadth about as 24 to 9, marginal, postmarginal, and stigmal veins approximately in the proportion of 25, 15, and 10, respectively. Abdomen longer than head and thorax combined, a little narrower than thorax, and fully three times as long as broad, the basal tergite smooth, the other tergites more or less sculptured, tip of ovipositor sheaths protruding a little beyond apex of abdomen.

General color greenish black; head below antennae, front coxae, mesosternum, and dorsum of abdomen tinged with coppery; propodeum metallic green; antennae entirely black; mandibles testaceous; coxae, trochanters, and femora black, tibiae yellow, the middle and posterior pairs with a little more than the apical one-third black; tarsi yellowish, the last two or three segments of each more or less fuscous; forewing subhyaline with a weak fuscous band at base of marginal vein and another incomplete one below stigmal vein; venation dark testaceous; hind wing hyaline

Type locality.—San Francisco, Calif.

Type.—U.S.N.M. no. 54701.

Described from one female collected May 13, 1915, by E. P. Van Duzee

Necremnus breviramulus, n. sp.

The male of this species is easily distinguished from other known males of the genus by the very short rami of the funicular joints. These branches are subequal and each less than twice the length of the main body of the segment from which it originates. The female differs from *maculatipennis* Ashmead and *californicus* (Girault) by having the forewings without infuscation, and it may be distinguished from *leucarthros* (Nees) by the much brighter metallic-green color of the body, by the somewhat shorter antennae, and by the less extensive infuscation of the posterior tarsi.

Female.—Length 2.2 mm. Head transverse, about as wide as thorax; lateral ocellus about twice its own diameter from eye margin; eyes with a few very short cilia; antennae inserted on or very slightly below a line joining the lower margins of the eyes, 9-jointed; scape subcylindrical, not attaining level of vertex; pedicel about one and one-half times as long as broad at apex; ring joint transverse, distinct; first funicular joint subequal in length to pedicel but slightly thicker; second and third joints of funicle each about as long as broad and very slightly shorter than first; club distinctly 3-jointed

and a little longer than the two preceding funicle joints combined, terminating in a distinct short spine. Whole head with fine, shallow, reticulate-punctate sculpture. Thorax sculptured about like the head; postscutellum about two-thirds as long as propodeum and sculptured like scutellum; propodeum with a distinct though delicate median longitudinal carina, without complete lateral folds but usually with distinct traces of them posteriorly, without spiracular sulci, and with its surface delicately reticulated, this sculpture very weak medially; prepectus distinctly more coarsely sculptured than rest of pleuron, the mesepimeron mostly smooth. Forewing extending beyond apex of abdomen, its length to breadth about as 22:9; marginal, postmarginal, and stigmal veins in about the proportions of 22, 10, and 7, respectively. Abdomen ovate, about twice as long as broad and about as long as head and thorax combined, nearly smooth but with some weak lineolation on the last three or four tergites; only the tip of ovipositor sheath exserted.

Head, thorax, and abdomen brilliant metallic green; antennal flagellum brownish; scape and pedicel metallic green; mandibles yellowish; legs metallic green or metallic fuscous, but with all trochanters, apices of all femora, anterior tibiae except ventrally, and middle and posterior tibiae at bases and apices pale yellow or whitish; each tarsus usually with the two basal joints white, the two apical joints fuscous; wings hyaline; venation pale yellowish; tegulae metallic green; abdomen beneath less brilliantly metallic than above.

Male.—Length 1 6 mm Antennal scape slightly thickened, about two and one-half times as long as broad; pedicel only a little longer than broad; ring joint apparently obsolete; first three joints of flagellum each about as broad as long and each with a short thick ramus originating at its base and extending beyond its apex approximately to apex of following segment; fourth flagellar joint about one and one-half times as long as thick, distinctly separated from the preceding and the following joints by short petioles and without a ramus; fifth and sixth flagellar joints separated only by a distinct groove, together forming a club which is approximately one and one-half times as long as the fourth flagellar joint and slightly constricted at apex but without the distinct terminal spine which is present in the female The abdomen is about as long as the thorax. In other respects the male is like the female.

Type locality --Lawrence, Kans.
Type.—U.S N.M. no. 54702.

Described from 31 females (1 holotype) and 8 males (1 allotype) said to have been reared from pupae of *Hypera eximius* Lec , June 6, 1936, by L. S Henderson. The holotype, allotype, and 18 paratypes are deposited in the U. S. National Museum Fifteen female and 4 male paratypes have been returned to the University of Kansas, whence the material was originally received.

Two females and 1 male reared at Pegrim, Ill , in October 1905 from *Hypera comptus* (Say) by E. S. G Titus are in the U. S. National Museum collection and are almost certainly this species but are not considered a part of the type material.

Necremnus oregonensis, n. sp.

Necremnus sp. Chamberlin, Proc. Ent. Soc. Washington 35: 107. 1933.

In color, size, and most every other respect, this species agrees with the description of *breviramulus*, but it differs from that species in the following particulars: Antenna of male with branches of funicular joints each about two and one-half to three times as long as the segment from which they orig-

inate and always extending well beyond the apex of the segment which follows; fourth flagellar joint of male more than twice as long as broad; first funicular joint of female distinctly a little longer than pedicel and about twice as long as broad; propodeum in both sexes with nearly uniform, distinct, fine, reticulate-punctate sculpture and without definite traces of the lateral folds.

Type locality.—Richmond, Oreg.

Type.—U.S.N.M. no 54703.

Described from 5 females (1 holotype) and 2 males (1 allotype) reared in July 1930 and June 1931 from *Hypera rumicis* (L.) by T. R. Chamberlin; also 2 females and 5 males reared July 5, 1931, by Chamberlin from material of *Hypera* sp. collected in the type locality.

Necremnus punctifrons Thomson

Necremnus punctifrons Thomson, Hym. Scand. **5**: 235. 1878.

According to the description, this European species has the postmarginal vein not longer than the stigmal, in which respect it differs from all the other species here treated. It is not known to occur in America and has not been seen by the writer.

Necremnus leucarthros (Nees)

Eulophus leucarthros Nees, Hym. Ichneumon affin. Mongr. **2**: 172. 1834.

Eulophus hippias Walker, Mongr. Chalcid. **1**: 185 1839.

Eulophus amempsimus Walker, Mongr. Chalcid. **1**: 186. 1839; Dalla Torre, Cat. Hym. **5**: 58. 1878; Thorpe, Proc. Ent. Soc. London **5** (pt 2): 30. 1930; Donisthorpe, Ent. Rec and Journ. Variation **50**: 74 1938 (New synonymy)

Necremnus leucarthros (Nees) Thomson, Hym. Scand. **5**: 234. 1878; Dalla Torre, Cat Hym. **5**: 7. 1898; Ruschka and Fulmek, Zeitsch. Angew. Ent. **2**: 398. 1915; Graham-Smith, Parasitology **11**: 371–383. 1919; Chamberlin, Journ. Econ. Ent **17**: 629. 1924; Proc. Ent. Soc Washington **27**: 142. 1925.

The type of *Eulophus leucarthros* Nees has not been seen by the writer, the present interpretation of the species being based on specimens identified by Thomson, Ruschka, and Schmiedeknecht. *Eulophus hippias* Walker was placed by Thomson as a questionable synonym of *leucarthros* The type of *hippias* in the British Museum was studied in 1927 and found to be the same as the current interpretation of *leucarthros* On the same occasion the types of *Eulophus amempsimus* Walker were examined, and that species is also believed to be the same as *leucarthros*.

Necremnus leucarthros was reared at the Salt Lake, Utah, Laboratory of the Bureau of Entomology from material imported from Europe in connection with the introduction of parasites for control of the alfalfa weevil, *Hypera variabilis* (Hbst.), but is not known to have been released in this country. The species is recorded by Ruschka and Fulmek as parasitizing *Lema cyanella* (L.) and by Graham-Smith as attacking Diptera. Thorpe records *Eulophus amempsimus* from *Hyponomeuta padellus* (L) and Donisthorpe cites it as a parasite of *Quedius brevis* Er.

Necremnus duplicatus, n. sp.

This species is extremely like *leucarthros* but may be distinguished in the male by the fact that the rami of the funicle joints are slender, cylindrical,

and sparsely clothed with long hairs. The female is not easily distinguished from *leucarthros*, differing, so far as I can see, only by being somewhat more robust, by having the abdomen broader in proportion to its length, and by the marginal vein being pale yellowish instead of brownish fuscous. The male antenna agrees with Thomson's characterization of *punctifrons*, but the postmarginal vein in that species is stated to be not longer than the stigmal, whereas in this species it is nearly one and one-half times as long as the stigmal.

Female.—Length 2 15 mm Head transverse, about as wide as thorax, viewed from in front a little broader than high; ocelli in a low triangle; lateral ocellus about twice its own diameter from eye margin; eyes with sparse short pile, antennae inserted very slightly above a line connecting lower margins of eyes, 9-jointed; scape subcylindrical, slightly compressed, attaining to level of anterior ocellus; pedicel not quite twice as long as broad, shorter and narrower than first funicular joint; ring joint strongly transverse; first funicular joint fully twice as long as broad; second and third joints of funicle subequal, each distinctly longer than broad but a little shorter than first; club very distinctly 3-jointed, about as long as two preceding joints combined and scarcely thicker than funicle, the first two joints subequal, the third joint smaller and terminating in a short spine. Whole head finely reticulate-punctate. Thorax sculptured about like head, the punctation on scutellum and axillae distinctly a little finer than on mesoscutum; postscutellum nearly as long as propodeum on median line and sculptured like scutellum; propodeum with a delicate median carina, usually without lateral folds but occasionally with faint traces of them posteriorly, without spiracular sulci, and with its surface uniformly very indistinctly reticulated, nearly smooth; prepectus more strongly sculptured than rest of pleuron; mesepimeron on upper half perfectly smooth. Forewing extending beyond apex of abdomen, its length to breadth about as 26 to 11; marginal, postmarginal, and stigmal veins about in the proportions of 27, 14, and 10, respectively. Abdomen broadly ovate, about as long as head and thorax combined and approximately one and one-half times as long as broad, the basal four segments practically smooth, those beyond the fourth weakly sculptured; only the apex of ovipositor sheath exposed.

Head and thorax dark green, more or less strongly tinged with coppery below antennae and on scutellum, axillae, and mesepimeron; mandibles yellowish; antennal scape and pedicel greenish black, flagellum brownish black; wings hyaline, the venation pale yellowish with the stigmal knob dark brown; all coxae concolorous with thorax, the anterior and median pairs tinged with coppery; trochanters dark; all femora greenish black with their apices narrowly yellow; front tibia blackish but with a pale-yellowish stripe on outer margin extending from base to apex; middle and posterior tibiae black with a narrow yellowish band at base of each; anterior tarsi wholly dark brown; middle and posterior tarsi with basal joint pale, the three following joints brownish or blackish; abdomen dark metallic green above, but with apex of first and greater part of second, third, and fourth tergites copper colored; ventral side of abdomen nearly black.

Male.—Length 1.7 mm Antennal scape not thickened, four or five times as long as broad; pedicel about one and one-half times as long as broad; ring joint obsolete; first funicular joint a little longer than pedicel and with a long, slender, cylindrical branch originating at its base and reaching very nearly to apex of flagellum; second funicular joint a little longer than first and with a similar branch originating somewhat beyond its base and likewise extend-

ing nearly to apex of flagellum; third joint a little longer than second, with its branch originating about at its middle and attaining to about the same point as the others; all the funicular rami sparsely clothed with long fine hairs; fourth joint of funicle nearly four times as long as broad, thicker toward apex than at base, and without a branch; club 2-jointed, a little thicker and very slightly longer than fourth funicular joint, its apical joint about half as long as the basal one and terminating in a very short spine; abdomen elliptical, about as long as thorax and about twice as long as broad, with its dorsum mostly dark cupreus. Otherwise like the female except less robust.

Type locality.—Mount Vernon, Wash

Type.—U.S.N.M. no. 54704.

Described from 20 females (1 holotype) and 21 males (1 allotype) reared from *Ceutorhynchus assimilis* (Payk) in turnip seed pods July 3, 1937, by A. J Hanson. A male and a female reared July 17–19, 1937, by H L. Parker, under European Parasite Laboratory no. 4377 from "Cruciferae pods" from Holland, seem to be this same species but are not considered a part of the type series Also in the collection are 8 specimens, believed to be this species, from Oakley, Hollister, Roseworth, and Castleford, Idaho, all swept from or collected on *Sophia sophia* and *Sisymbrium altissimum* in June 1937 and in May and June 1931. The specimens collected in 1931 were taken by David E. Fox, but the collector of the earlier specimens is not known

ENTOMOLOGY.—*Revision of the Nearctic Megophthalminae (Homoptera: Cicadellidae).*[1] P. W. OMAN, U. S. Bureau of Entomology and Plant Quarantine.

This paper deals with the North American leafhoppers heretofore assigned to the genus *Paropulopa* Fieber. According to the present interpretation none of the seven known species, representing two genera herein described, is congeneric with the European *Paropulopa lineata* Fieber, 1866, genotype of *Paropulopa*.

Paropulopa lineata Fieber has no ocelli, the ocellar vestiges being on the crown rather than on the face, whereas in all the North American species of Megophthalminae the ocelli are present and located on the face. This character is sufficient to distinguish the North American forms from *Paropulopa*, and they may be differentiated from *Megophthalmus* Curtis,[2] to which they seem more closely related, by the fact that the carinae replacing the frontal and epicranial sutures are not foliaceously produced. Because these leafhoppers are rather rare in collections and the characters of the subfamily are not well known, the following résumé of the characters common to the North American representatives seems appropriate.

Relatively small, robust leafhoppers (2.5–5 mm in length); color some shade of cinereous, brown, or fuscous; head, including eyes,

[2] *Megophthalmus* Curtis, January 1833, genotype (*Megophthalmus bipunctatus* Curtis, 1833) = *Cicada scanica* Fallen, 1806; synonym *Paropia* Germar, March 1833, genotype (*Cicada*) *Ulopa scanica* (Fallen), 1806 (= *Coelidia ? scutata* Germar, 1821).

distinctly wider than pronotum; eyes somewhat bulbous; clypeal suture distinct; frontal sutures replaced by carinae above antennal pits; clypellus elongate and narrowed slightly both basally and distally, extending well beyond the normal curve of the genae; gena strongly emarginate below eye; length of antenna about one-half width of head; antennal pit shallow, with only a very small ledge above; distance between ocelli equal to or greater than distance from ocellus to eye; ocellus located at the inner end of a more or less distinct transverse depression formed by the frontal carina and the dorsal margin of the face, the ocellus thus directed laterad or laterocephalad; head, pronotum, scutellum, and at least basal portion of forewing, excepting the veins, with numerous small, circular pits; forewing subcoriaceous, veins usually rather prominent, appendix absent.

In distribution the species treated in this paper appear limited to California and adjacent Mexico west of the Sierras, and locality records given for the various species are in California unless otherwise indicated.

The illustrations accompanying this paper were made on coordinate paper with the aid of a micrometer scale placed in the ocular of a compound microscope. Corresponding parts are drawn to the same scale and therefore give an accurate idea of the relative size of the various structures in the different species. For convenience in examining these figures corresponding structures are indicated by the same letter, as follows: A, lateral view of dorsal spine; B, dorsal view of style and connective; C, lateral view of aedeagus; D, ventral view of male plates, from dissected specimens; E, dorsal view of head, pronotum, and scutellum; F, ventral view of female sternite VI, G, ventral view of female sternite VII. These letters are in each instance associated with a number indicating the species, as follows: 1, *Brenda arborea* (Ball); 2, *Tiaja mexicana* (Ball); 3, *T. interrupta* (Ball); 4, *T. californica* (Ball); 5, *T. ventura*, n. sp.; 6, *T. friscana* (Ball); 7, *T. montara*, n. sp.

In choosing the cotype specimens herein designated as lectotypes of the various species, I have in each case selected the specimen to which Ball had attached his name label.

KEY TO GENERA AND SPECIES OF NEARCTIC MEGOPHTHALMINAE

a^1. Hindwings fully developed. Crown broad and short, median length not greater than length next to eye (Fig. 1E) . .   .*Brenda,* n. gen.
        One species, *Brenda arborea* (Ball)

a^2 Hindwings rudimentary. Crown distinctly longer medially than next to eye (Fig. 4E).. .   .. .   *Tiaja,* n. gen.

  b^1. Vein Cu_1 not forming a claval suture but evident as a vein throughout its length. Veins adjacent to Cu_1 (Cu_1 and first claval) at no point elevated above level of Cu_2 .   *T. mexicana* (Ball)

b^2. Vein Cu₂ either obscure or appearing as the claval suture for at least part of its length. Veins adjacent to Cu₂ (Cu₁ and first claval) usually distinctly elevated above level of Cu₂ opposite the furcation of radius and media.

   c^1. Sternite VII of female usually visible only laterally, always shorter medially than laterally and median length always less than median length of sternite VI. Male plates rather small, appearing (unless relaxed and dissected) subtruncate distally Dorsal spine slender, distal portion attenuated .   *T. interrupta* (Ball)

   c^2. Sternite VII of female visible throughout its width, not shorter medially than laterally, or if so due to a broad, shallow, median emargination posteriorly and then with median length equal to or greater than median length of sternite VI. Male plates large, never appearing subtruncate, but with caudolateral margins deflexed. Dorsal spine stout, distal portion not attenuated.

      d^1. Sternite VII of female with a median U-shaped emargination posteriorly (Fig 4G) Dorsal spine with four hooklike points distally (Fig. 4A)   *T. californica* (Ball)

      d^2. Sternite VII of female without a median U-shaped emargination posteriorly. Dorsal spine with not more than three points distally

         e^1 Females.

           f^1. Sternite VII truncate or nearly so. Basal margins of pygofer exposed.

              g^1. Basal margins of pygofer not deflexed . .*T. ventura*, n. sp

              g^2. Basal margins of pygofer strongly deflexed
                                    T friscana (Ball)

           f^2 Sternite VII with a broad, shallow, median emargination posteriorly. Basal margins of pygofer covered by sternite VII.
                                    T. montara, n. sp.

         e^2. Males

           h^1. Style not extending beyond apex of plate
                                  T. ventura, n sp

           h^2. Style extending well beyond apex of plate.

              i^1 Style with distal portion attenuated (Fig 6B)
                                .*T. friscana* (Ball)

              i^2. Style with distal portion expanded (Fig. 7B) . .
                                . *T montara*, n sp

Brenda, n gen.

Face broad and relatively flat; ocellar depressions very shallow; crown short and broad (Fig. 1E), with nearly parallel margins, median one-third with a very shallow transverse depression. Pronotum broadly arched except for a pair of broad, shallow depressions anterolaterally; lateral margins short. Venation of forewing normal, with three discal and three anteapical cells. Hindwing fully developed, with four apical cells; costal area very broad at apex of wing.

Type of the genus, *Paropulopa arborea* Ball, 1909.

Brenda arborea (Ball), n. comb

Paropulopa arborea Ball, Can Ent 41: 184. 1909
    Length 3 4–3.9 mm. Anterior margin of head sharply angled Circular pits on forewing sparse, occurring only on basal half along veins.
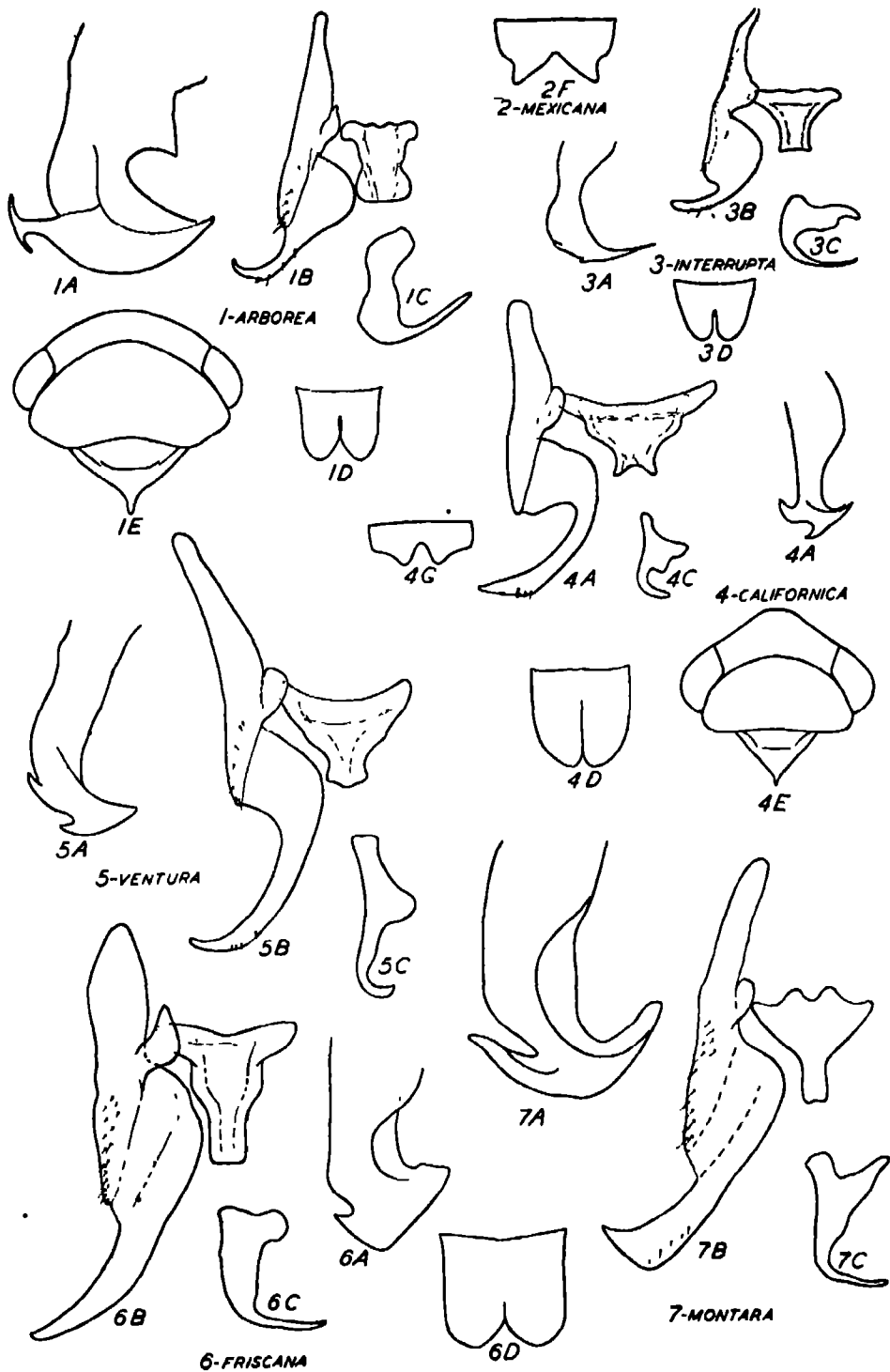
Figs. 1–7.—(See opposite page for explanation.)

Color variable, usually some shade of brown and typically golden-brown, but frequently with considerable cinereous. Fuscous marks, if present, always more extensive on the venter; on the dorsum usually confined to the circular pits but occasionally forming a faint and poorly outlined band across middle of forewing.

Sternite VII of female very short, usually less than one-third the length of sternite VI and frequently not apparent as a separate sternite, posterior margin truncate Basal portions of ovipositor, ovipositor sheath, and pygofer exposed. Male valve small, nearly quadrangular in outline. Male plates small, rounded distally (Fig. 1D). Dorsal spine heavily sclerotized and pigmented, usually visible without dissection, in lateral view as illustrated (Fig. 1A). Style, connective, and aedeagus relatively simple, outlines as illustrated (Figs 1B, 1C).

Distribution.—Cold Springs, Sequoia National Forest (Oman); Colfax (Ball); El Portal (Oman); Palo Alto (Oman), Sloughhouse (Cartwright); Towle (Beamer); Watsonville (Ball); Yosemite Valley (Beamer) All these localities are in central California west of the Sierras April 29 to August 20 62 specimens examined.

Lectotype female labeled "Colfax, Cal 23 Je 08" in the E D. Ball collection, U. S. National Museum

Tiaja, n gen.

Face moderately convex below the level of the antennal pits, above this line with a distinct median depression between the two rather deep ocellar depressions; crown distinctly longer medially than next to eye (Fig 4E), nearly flat or with a shallow depressed area on disk Pronotum scarcely arched, slightly elevated along the median line, thus accentuating somewhat the broad, shallow, antero-lateral depressions, lateral margins short; posterior margin truncate or slightly emarginate medially Venation of forewing frequently irregular and usually with additional cross veins in the apical portion Hindwings rudimentary.

Type of the genus, *Paropulopa californica* Ball, 1909

Tiaja mexicana (Ball), n comb.

Paropulopa mexicana Ball, Can Ent. **34**: 22. 1902

Length 3.6 mm Clypeus comparatively tumid, frontal carinae not so prominent as is usual in the genus; anterior margin of head rather blunt Forewing long and rather narrow, distally narrowing about equally from both margins; apex bluntly pointed, Cu_2 evident as a distinct vein, not as the claval suture; circular pits distributed rather evenly over entire forewing

Color testaceous-brown, irregularly marked with fuscous on head and pronotum. Media of forewing marked with brown on distal half

Sternite VII of female evident only as a broad, somewhat membranous flap medially, almost completely covered by the large sternite VI, the posterior margin of which is produced into a pair of bluntly pointed, divergent, triangular projections laterally, thus forming a broad, flaring V-shaped median emargination (Fig. 2F). Male unknown.

Distribution.—Sierra Madre Mountains, Chihuahua, Mexico, altitude about 7,200 feet. Date unknown. Known only from two female cotypes.

Lectotype female labeled "Sr. Madre Mts. Mex." in the E D Ball collection, U S. National Museum.

Figs. 1–7.—Leafhoppers of the subfamily Megophthalminae: 1, *Brenda arborea* (Ball); 2–7 species of *Tiaja* For identification of various detailed drawings see explanation in introductory remarks.

Tiaja interrupta (Ball), n. comb.

Paropulopa interrupta Ball, Can. Ent **34**: 21. 1902.

Length 2.5–3 mm. Anterior margin of head somewhat variable but usually rather sharp, always more distinctly angled than in *mexicana*. Forewing with costal margin more strongly curved than commissural margin, apex bluntly pointed; claval suture (Cu₂) rather obscure basally; Cu₁ and 1st claval slightly elevated above Cu₂ opposite furcation of radius and media; circular pits rather sparse and arranged mostly in single rows along veins.

Color very variable, showing almost every possible intergradation from uniform pale testaceous-brown or cinereous with a few fuscous marks to fuscous with a few cinereous marks, typically about equally fuscous and cinereous with an irregularly mottled appearance.

Sternite VII of female very short, usually visible for its entire length but occasionally visible only laterally Male valve small, truncate posteriorly, a little wider basally than distally. Male plates small appearing (unless relaxed and dissected) subtruncate distally and with lateral margins nearly straight, in dissected specimens outline as illustrated (Fig 3D). Dorsal spine with distal portion attenuated and with a pair of small, blunt, hook-like projections on the ventral surface, in lateral view as illustrated (Fig 3A). Style, connective, and aedeagus simple, outlines as illustrated (Figs 3B, 3C).

Distribution —Beaumont (Ball), Cabazon (Ball); Carlsbad (Beamer); Cuyamaca Lake (Beamer), Del Mar (Oman); Hurkey Creek, San Jacinto Mts (Oman); Jacumba (Oman); La Mesa (Ball); Los Angeles Co (Coquillett, Koebele); Miramar (Beamer), Newton (Oman); Ontario (Ball); Pasadena (Ball, Fall); San Diego (Ball, Beamer); Tia Juana (Ball) MEXICO: Tia Juana (Ball). Apparently confined to rather low altitudes in southern California and adjacent Mexico west of the Imperial Valley June 1 to August 6; 135 specimens examined.

Lectotype female labeled "Los Angeles Co, Cal, Collection Coquillett" in the U. S. National Museum, no 6096.

Tiaja californica (Ball), n. comb.

Paropulopa californica Ball, Can. Ent. **41**: 184 1909.

Length 2 8–3 2 mm. Head, pronotum, and scutellum as illustrated (Fig 4E) Anterior margin of head distinctly angled Forewing usually with costal margin distally more strongly curved than commissural margin, sometimes the two margins about equally curved, apex bluntly pointed; Cu₂ and circular pits as in *interrupta*.

Color varying from uniform pale testaceous-brown or uniform cinereous with a few brown marks to brownish fuscous with numerous cinereous marks, typically the ground color of pale testaceous-brown and cinereous with irregular markings of fuscous and brown.

Sternite VII of female short laterally, posterior margin with a bluntly rounded projection each side of a flaring U-shaped median emargination (Fig 4G). Male valve short, truncate posteriorly and distinctly broader basally than distally. Male plates rather large, appearing (unless relaxed and dissected) nearly parallel sided, distally rounded and but little incised on median line, caudo-lateral margins slightly deflexed, in dissected specimens the outline as illustrated (Fig. 4D). Dorsal spine ending in four hook-like points, two rather long and directed caudad, two short and directed cephalad (Fig. 4A). Style, connective, and aedeagus as illustrated in outline (Figs. 4B, 4C), the aedeagus unusually small in comparison with the aedeagi of other members of the genus.

Distribution.—Burlingame (Oman); Honda (Oman); Leona Heights (Beamer); Montara (Oman); Monterey (Beamer); Niles (Beamer); Salinas (Ball); Sargent (Beamer). These localities are all in the low hills south and east of San Francisco Bay. April 26 to July 22; 182 specimens examined.

Lectotype female labeled "Salinas, Cal., 20 Je. '08, E D Ball Collector" in the E. D. Ball collection, U. S. National Museum.

Tiaja ventura, n. sp.

Length 3.2–4 mm. Frontal carinae prominent; anterior margin of head sharply angled, occasionally subfoliaceous. Forewing with costal margin distally more strongly curved than commissural margin; apex bluntly pointed; Cu_1 and 1st claval distinctly elevated above claval suture opposite furcation of radius and media; circular pits obscure but present along veins.

Color cinereous, sometimes tinged with testaceous-brown, and usually irregularly marked with brown or fuscous

Sternite VII of female short, posterior margin truncate or nearly so Exposed basal margins of female pygofer slightly thickened but not deflexed Male plates as in *californica* but proportionately a little broader Dorsal spine with one rather blunt point and two hook-like projections distally, in lateral view as illustrated (Fig. 5A). Style, connective, and aedeagus as illustrated in outline (Figs. 5B, 5C).

Distribution —Gaviota (Beamer); Oxnard (Ball), Pismo Beach (Beamer), Santa Barbara (Ball). All these localities are along the coast north of Los Angeles. April 25 to July 25; 198 specimens examined.

Holotype male, allotype female, and numerous paratypes of both sexes from Pismo Beach, Calif., July 19, 1933, R. H. Beamer Holotype, allotype, and paratypes in collection of University of Kansas, paratypes in collection of U S. National Museum, no 55132.

For this species I have adopted the manuscript name applied to it by Dr. E D Ball, who recognized it as new.

Tiaja friscana (Ball), n comb.

Paropulopa friscana Ball, Can. Ent **41**: 183. 1909.

Length 4–5 mm. Anterior margin of head sharply angled but not so thin as in *ventura;* crown proportionately much shorter than in Fig. 4E (*californica*) but always distinctly longer medially than next to eye Forewing with costal and commissural margins about equally curved distally; apex blunt, scarcely pointed, claval suture (Cu_2) obscure basally; Cu_1 and 1st claval usually distinctly elevated above level of Cu_2 opposite furcation of radius and media; circular pits not restricted to rows along veins.

Color pale testaceous-brown or cinereous with irregular brown or fuscous marks. Apparently not so variable in color as *interrupta* and *californica.*

Sternite VII of female short, posterior margin truncate and usually slightly deflexed, at least medially. Exposed basal margins of female pygofer strongly deflexed. Male valve broad and very short, basal margin but little longer than distal margin Male plates broad, apices broadly rounded and separated by a flaring v-shaped median incision distally (Fig. 6D), the caudolateral margins strongly deflexed. Dorsal spine heavily sclerotized and pigmented, visible without dissection, in lateral view as illustrated (Fig 6A). Style long, distal portion attenuated, heavily sclerotized and pigmented and extending well beyond plate, outline of style and connective as illustrated (Fig 6B). Aedeagus as illustrated in outline (Fig. 6C).

Distribution.—Known only from the San Francisco Bay region (Ball,

Beamer, Bridwell, Oman, Van Duzee). March 30 to September 9; 34 specimens examined.

Lectotype female labeled "S Francisco, Cal , 27 Ap. 08, E. D. Ball Collector" in the E D. Ball collection, U. S. National Museum.

Tiaja montara, n sp.

Length 3 8–4.1 mm. Anterior margin of head sharply angled; crown proportionately much shorter than in Fig. 4E (*californica*) but always distinctly longer medially than next to eye. Forewing as in *friscana*.

Color pale testaceous-brown or cinereous with a few irregular brown or fuscous marks. Veins of distal two-thirds of corium of forewing marked with fuscous in some specimens The small series at hand is rather uniform in color but considerable variation may be expected

Sternite VII of female as long or longer than sternite VI, posterior margin broadly and shallowly emarginated Basal margins of female pygofer covered by sternite VII. Male valve and plates as in *friscana*. Dorsal spine heavily sclerotized, distally with a pair of hook-like projections of about equal size, one directed caudad and one cephalad, in lateral view as illustrated (Fig. 7A) Style extending well beyond plate, the apex broad and subtruncate, the subtruncated margin slightly deflexed, outline of style and connective as illustrated (Fig. 7B). Aedeagus as illustrated in outline (Fig 7C).

Holotype male, allotype female, and three female paratypes from Montara, Calif , June 13, 1935, P W. Oman Known only from the type material Types in collection of U. S. National Museum, no 55132.

PROCEEDINGS OF THE ACADEMY
AND AFFILIATED SOCIETIES

THE ACADEMY

367TH MEETING OF THE BOARD OF MANAGERS

The 367th meeting of the Board of Managers was held in the Library of the Cosmos Club on Friday, March 14, 1941. President CLARK called the meeting to order at 8:08 P M., with 21 persons present, as follows: A. H. CLARK, F. D ROSSINI, H S RAPPLEYE, N R SMITH, W. W. DIEHL, J. H. KEMPTON, J. H HIBBEN, J. E. GRAF, F H H ROBERTS, JR , F G. BRICKWEDDE, E. P. WALKER, R. M HANN, W A. DAYTON, H. L CURTIS, W. RAMBERG, J. R CHRISTIE, L W. PARR, C L GARNER, and, by invitation, R J. SEEGER, G. A. COOPER, and F. C KRACEK

The minutes of the 366th meeting were read and approved.

President CLARK announced the following appointments:

(a) Committee to Consider the Publication of a Directory of the Academy for 1941. A H CLARK (chairman), H. L CURTIS, J. E GRAF, H. S. RAPPLEYE, F. D ROSSINI, and N. R SMITH.

(b) Committee to Survey the Academy's Investments and Deposits: H. S. RAPPLEYE (chairman), A. T. McPHERSON.

(c) Committee on Awards for Scientific Achievement for 1941: General chairman, J. M. COOPER; For the Biological Sciences, J. M COOPER (chairman), F. O. COE, H. A. EDSON, E. A. GOLDMAN, I. T. HAIG, C F. W. MUESEBECK, H W. SCHOENING, G. STEINER, and A. WETMORE; for the Engineering Sciences, H. G. DORSEY (chairman), C. H. BIRDSEYE, F. M. DEFANDORF, J H DELLINGER, A. C FIELDNER, P. A. SMITH, and P C. WHITNEY; for the Physical Sciences, W. E. DEMING (chairman), W. G.

BROMBACHER, F. G COTTRELL, L. V. JUDSON, S. KARRER, F. E JOHNSTON, H. E. McCOMB, P. G. NUTTING, E. W POSNJAK, and F. O. RICE.

The Committee on Membership, F. C. KRACEK, chairman, presented nominations for membership for eight persons (seven resident and one nonresident).

The Board considered individually and duly elected to membership the five persons (all resident) whose nominations had been presented on February 7, 1941.

The Committee to Consider the Publication of a Directory of the Academy for 1941, A. H. CLARK, chairman, presented a report recommending the following: (a) that a Directory of the Academy and its Affiliated Societies for 1941 be published, at a cost to the Academy not to exceed $350; (b) that this Directory be produced by the photolithographic process, (c) that the present size of the Directory be retained; (d) that the color of the cover be red; and (e) that the contents be as follows:

I. The Academy
   1. History and present status
   2. Officers and committees for 1941*
   3. Past presidents
   4 Bylaws and standing rules
   5. Patrons
   6 Honorary members
   7 Nonresident members, listed alphabetically, with name, institution, and place
   8 Resident members
      a. Listed alphabetically, with name, institution, place, and societies
      b Listed by institutions
   9. Deceased members
II. Philosophical Society of Washington
   1. History and present status
   2. Officers and committees for 1941†
   3. Members, listed alphabetically, with name and institution
III to XX Remaining 18 affiliated societies, similarly arranged, except that no list of members is given for the Geographical Society and the Archaeological Society

The Board approved this report and instructed the President to appoint a Committee, consisting of the Secretary and the Treasurer, to publish a Directory of the Academy for 1941 in accordance with the recommendations of the Committee, with the additional proviso that, if feasible, there be included for members of the Academy the year of their election.

The Secretary presented the following information with regard to changes in membership since the last meeting of the Board: Deaths, 1; acceptances to membership, 8; qualified for membership, 10 resident and 7 nonresident; retirements, 2; resignations, 2. The status of the membership, as of March 13, 1941, was as follows:

	Regular	Retired	Honorary	Patrons	Total
Resident	425	33	3	0	461
Nonresident	128	15	14	3	160
Total	553	48	17	3	621

* Provision will be made for inserting similar data for 1942 and 1943.
  † If possible and desirable, provision will be made for inserting similar data for 1942 and 1943

The Senior Editor, J. H. KEMPTON, asked the Board to approve the transfer of two of the three complete bound sets of the Journal in the hands of the Editors to the Custodian and Subscription Manager of Publications in order that the latter might have these available for sale to new institution-subscribers. The Board approved this request with thanks to the Editors.

The Custodian and Subscription Manager of Publications, W. W. DIEHL, reported the sale of one complete set of 30 volumes of the Journal.

President CLARK reported the resignation of G. STEINER from the Board of Managers because of the press of his work To fill this vacancy for 1941, the Board elected F. C. KRACEK.

The Chairman of the Committee on Meetings, C. L. GARNER, reported on the plan of the Scientific Monthly to publish a monthly *Calendar of Scientific Meetings in Washington* and to make these available to the Academy and the various Societies at one-half cent per copy. The Board authorized the Secretary to send out copies of the calendar to all members with the next six mailings of notices of meetings of the Academy, the expenses to be paid from the regular budget of the Secretary.

The meeting adjourned at 9:40 P.M.

304TH MEETING OF THE ACADEMY

The 304th meeting of the Academy was held in the Assembly Hall of the Cosmos Club at 8:15 P M. on Thursday, March 20, 1941, with President A. H. CLARK presiding The meeting was devoted to the presentation by the Academy of its *Awards for Scientific Achievement for 1940*, as follows:

For the *Physical Sciences*, to FERDINAND G. BRICKWEDDE, Chief of the Cryogenic Laboratory of the National Bureau of Standards, for his distinguished service in assisting in the discovery of deuterium, in low-temperature researches on the different modifications of hydrogen, and in the development of a working scale of temperature in the range 14° to 83° K.

For the *Engineering Sciences*, to HARRY DIAMOND, Principal Physicist in the Radio Section of the National Bureau of Standards, for his distinguished service in developing radio methods for aircraft navigation, especially in "blind landing," and for upper-air meteorological soundings, including the radio sonde, and in the development of an automatic weather reporting station.

LYMAN J BRIGGS, Director, and EUGENE C. CRITTENDEN, Assistant Director, of the National Bureau of Standards, introduced the recipients, who each gave a brief address concerning particular phases of the work for which the awards were made.

There were about 70 persons present. The meeting adjourned at 9:55 P M. for a social hour.

NEW MEMBERS

The following persons have recently been elected to membership in the Academy:

Resident

RICHARD ELIOT BLACKWELDER, assistant curator, Division of Insects, U. S. National Museum, in recognition of his contributions to our knowledge of the West Indian Coleoptera.

FRANK P. CULLINAN, senior pomologist, U. S Bureau of Plant Industry, in recognition of his researches in pomology, in particular with regard to apple and peach nutrition, pruning, stone fruit production, and carbohydrate-nitrogen relationships in peach shoots

WALLACE JOHN ECKERT, head astronomer and director of the Nautical Almanac Office at the U. S. Naval Observatory, in recognition of his fundamental work in adapting the "punched-card" method to scientific computations, particularly in the field of astronomy

AUREL OVERTON FOSTER, assistant zoologist, U S. Bureau of Animal Industry, in recognition of his contributions to knowledge of hookworm disease, particularly with regard to anemia, prenatal infection, physiological strains, and host migration

IRA BOWERS HANSEN, associate professor of zoology, George Washington University, in recognition of his researches on the anatomical effects of endocrines and of his services to science as a teacher of biology.

JOHN THOMAS LUCKER, associate zoologist, U S Bureau of Animal Industry, in recognition of his contributions to the ecology of larval and adult nematode parasites of domestic animals.

EDWARD GEORGE REINHARD, professor and head of the department of Biology, Catholic University of America, in recognition of his researches in embryology and hydrobiology, particularly with regard to the habits of solitary wasps, plankton, and experimental embryology

LAWRENCE W SAYLOR, assistant biologist, U S Fish and Wildlife Service, in recognition of his contributions to systematic coleopterology, and in particular his work on the scarab beetles of North, South, and Central America.

THEODOR VON BRAND, associate professor of biology, Catholic University of America, in recognition of his researches on the physiology of invertebrates, particularly with regard to their metaboism.

JAMES FRANKLIN YEAGER, senior entomologist, U S Bureau of Entomology and Plant Quarantine, in recognition of his researches on the general and comparative physiology of insects.

Nonresident

JOSEPH EVERETT ALICATA, parasitologist, Experiment Station, University of Hawaii, Honolulu, Hawaii, in recognition of his work in morphology, taxonomy, parasitic Protozoa and spirochaetes, immunity in metazoan parasites, and the life history of helminths.

ARTHUR CHALLEN BAKER, principal entomologist, U. S. Bureau of Entomology and Plant Quarantine, Colonia Anahuac, Mexico, in recognition of his work on fruit flies, tropical entomology, and the classification and biology of Aphidae.

WALTER E DOVE, principal entomologist, U. S. Bureau of Entomology and Plant Quarantine, Panama City, Fla , in recognition of his work on overwintering of the house fly, bots of horses, creeping eruption, warbles of rein-

deer, goat lice, tropical rat mites, sand flies, dog and cat hookworms, and transmission of endemic typhus.

HOWARD SAMUEL FAWCETT, professor and head of the Department of Plant Pathology, Citrus Experiment Station, University of California, Riverside, Calif., in recognition of his work on citrus pathology, including his recent treatise on citrus diseases.

RUDOLF WILLIAM GLASER, associate member, Rockefeller Institute for Medical Research, Princeton, N. J., in recognition of his work in physiology, pathology, bacteriology, protozoology, and mycology of insects, and his work on virus diseases in plants, intracellular symbionts and reckettsiae, cultivation of Protozoa in the pure state, and nematode parasites on insects.

HAROLD FREDERICK LOOMIS, associate agronomist, U. S. Bureau of Plant Industry, Coconut Grove, Fla., in recognition of his contributions to the systematic classification of millipeds and to agronomic investigations on cotton grown under irrigation.

FRANK PADEN MCWHORTER, plant pathologist, Oregon State College, Corvallis, Oreg , in recognition of his work on the ecology of cryptogams, protozoan diseases of plants, parasitic phanerogams, vegetable pathology, diseases of ornamental plants and truck crops, diseases of tomatoes, tropical fruits, and virus diseases of plants.

RALPH ROBINSON PARKER, director of the Rocky Mountain Laboratory, U. S. Public Health Service, Hamilton, Mont., in recognition of his work on Rocky Mountain spotted fever and tularemia.

HOWARD SPRAGUE REED, professor of plant physiology, University of California, Berkeley, Calif , in recognition of his work in plant physiology, his book entitled *A manual of bacteriology*, and his work on the history of botany since 1801

NORMAN RUDOLPH STOLL, associate member, Rockefeller Institute for Medical Research, Princeton, N J., in recognition of his work on the biology of free-living stages of hookworm, severity of hookworm infection, hookworm in the American Tropics and China, self-cure and protection against nematodes by sheep, *Haemonchus, Monieza*, and culture of parasitic nematodes.

MARCELLUS HENRY STOW, professor and head of the Department of Geology, Washington and Lee University, Lexington, Va., in recognition of his researches in sedimentary petrography, and on the petrography and stratigraphy of the Oriskany formation and of the Bighorn Basin.

ORLAND EMILE WHITE, professor of agricultural biology and director of the Blandy Experimental Farm, University of Virginia, Charlottesville, Va., in recognition of his work in experimental biology, physical bases of inheritance, genetics of tobacco, peas, and castor-oil beans, and origin of cultivated plants.

<div style="text-align:right">FREDERICK D. ROSSINI, Secretary</div>

Obituaries

DAYTON CLARENCE MILLER, professor emeritus of physics, Case School of Applied Science, died in Cleveland, Ohio, on February 22, 1941. He was born in Strongsville, Ohio, on March 13, 1866, and received the Ph.B. and M.A. degrees from Baldwin University in 1886 and 1889 and the D Sc. degree from Princeton University in 1890 He was professor of natural science at Baldwin University in 1888–89. Following graduation from Princeton University he began his long career of distinguished service at the Case School of Applied Science, starting as instructor in mathematics and physics in 1890, becoming assistant professor of physics in 1893 and professor of physics in 1895, which position he held until his retirement recently as professor emeritus. He had been a trustee of the Baldwin-Wallace College since 1899 and since 1936 had served as chairman of the board of trustees

Professor Miller published numerous scientific papers on investigations of the velocity of light in magnetic fields, the expansion of gases, Roentgen rays, the relative motion of the earth and ether, the efficiency of the incandescent gas light, applications of the interferometer, photographic registration of sound waves, and the quality of musical sounds He was also the author of seven books, the first (1903) on *Laboratory physics* and the last (1939) on *Sparks, lightning, cosmic rays*. The other books dealt with acoustical and musical subjects.

Professor Miller is probably best known for his investigations of the relative motion of the earth and ether and for his fine collection of flutes This collection, which illustrates the development of the flute from very early times, contains nearly 1,000 musical instruments and is believed to be the world's largest The collection began as an avocation but became the inspiration of some important contributions to the acoustical science of music and to the development of an improved flute It has been bequeathed to the Library of Congress and thus becomes a valuable heritage of all the people. A gold flute, made in accordance with Professor Miller's directions, has been used by symphony orchestras with brilliant effect in certain passages.

His work in the field of acoustics was widely recognized He studied acoustics in relation to auditorium design and drew the specifications for some of the large auditoriums throughout the United States. Among these auditoriums are Severance Music Hall, the Epworth-Euclid Methodist Church, and the First Church of Christ, Scientist, in Cleveland, and the chapels at Denison University, Bryn Mawr College, Princeton University, the University of Chicago, and also the acoustics of the National Academy of Sciences Building in Washington, D. C. In addition to these, Dr. Miller designed specifications for about a hundred other churches, theaters, hospitals, offices, and large and small auditoriums.

Professor Miller was honored with the Longstreth Medal of the Franklin Institute, the Elliott Cresson Medal, and the Cleveland Distinguished Service Medal. He held honorary degrees from Miami University in Ohio, Dartmouth College, Western Reserve University, Baldwin-Wallace College, and Case School of Applied Science and was a member of a number of scientific societies in some of which he held important offices. He was a nonresident vice-president of the Washington Academy of Sciences in 1922 and president of the American Physical Society in 1925 and the Acoustical Society of America in 1931–32 Professor Miller's long continuous period of service in the American Physical Society began in 1914 when he was elected to the

Council of the Society and extended without interruption to his death when he was serving on the Council as a past president. It was a matter of great satisfaction to Professor Miller and to his many friends that in that long period he had been able to attend, with only a very few exceptions, every meeting of the Council and the Society.

Professor Miller will be long remembered by his many friends and acquaintances for his scholarly attainments and for his gentle and courteous manners.

WILLIAM WILLIAMS GILBERT, senior pathologist, Division of Fruit and Vegetable Crops and Diseases, U S. Bureau of Plant Industry, died at Washington, D. C., on December 22, 1940. He had been in ill health for some months, but with surprising courage carried on his official duties almost to the hour of his death, the immediate cause of which was a cerebral hemorrhage.

Mr. Gilbert was born in Dorset, Vt , on September 17, 1880, and was graduated from the University of Vermont in 1904 with the B.S.A. degree and Phi Beta Kappa honors. In 1909 he was awarded an M.S. degree in plant pathology by the University. He did postgraduate work at the University of Wisconsin, George Washington University, and in the Graduate School of the Department of Agriculture.

In 1904 he was appointed a scientific assistant in the office of cotton and truck crop diseases, Bureau of Plant Industry, assisting the late Dr. W. A. Orton in breeding disease-resistant varieties of cotton, watermelons, and cowpeas During the early years of his Department service—and he spent his entire scientific life in the Department of Agriculture—he worked mainly in the Southern States and was charged with much of the responsibility for the investigations of the office there Later, as Dr. Orton's health became impaired, Mr. Gilbert spent most of his time in Washington, assuming general administrative charge of the office. When the office was consolidated with the new Division of Fruit and Vegetable Crops and Diseases, Mr. Gilbert was drafted to fill the position of subject-matter specialist in charge of publications, his technical background fitting him admirably for this work. This position he held until his death, his spirit of helpfulness and his infinite supply of tact proving invaluable

He was a member of the Botanical Society of Washington, the Washington Academy of Sciences, the Botanical Society of America, the Vermont Botanical Society, and a charter member of the American Phytopathological Society, as well as a Fellow of the American Association for the Advancement of Science. He was the author of more than a score of bulletins and scientific papers dealing with plant pathological problems.

Mr. Gilbert's entire life was marked by an outstanding spirit of service and a persistent adherence to the highest ideals in his official work, his church activities, and in the various community projects to which he lent his aid. He was a member of the Board of Trustees of the First Congregational Church of Washington, D C., and served as secretary of the Board. For many years he was also a trustee of the Congregational Home for the Aged.

His wife, the former Ottonie Ulickson, died in 1937. He is survived by a son, Henry Philip Gilbert, of Washington, D. C.

ASTROPHYSICS.—*The constitution of diffuse matter in interstellar space.*[1] OTTO STRUVE, Yerkes Observatory. (Communicated by EDWARD TELLER.)

THE EMPTINESS OF SPACE

On a clear moonless night we can see with the unaided eye somewhere between 2,000 and 3,000 stars. With an average pair of binoculars the number of visible stars is increased to about 10,000, and on long exposures taken with the largest existing telescope the number would be 2 or 3 billion. If we recall that the entire celestial sphere contains 41,253 square degrees and that the visible area of the full moon is about one-fifth of a square degree, we find that there are at least 10,000 stars within the reach of our most powerful instruments for every area of the sky equal to the full moon. If we remember also that the number of invisible stars—too faint to be recorded even with the 100-inch Mount Wilson reflector—is at least thirty times greater, and that near the Milky Way the concentration of stars is roughly one hundred times greater than at the poles of the galaxy, we find that in many regions of the Milky Way the apparent star density must be of the order of 30 million for an area equal to the disk of the moon. It is not surprising that on the best photographs of the Milky Way the images of the stars are so densely crowded together that they flow into one another and give the appearance of an almost continuous mass of stars.

But this impression is misleading. In reality the individual stars are separated by distances of several light years, and if we liken the stars to raindrops their average distances would have to be 40 miles to give us the right idea of the density within our galaxy of matter in the form of stars. For every cubic centimeter of stellar matter there are 10^{22} cubic centimeters of transparent space. Our galaxy is a relatively dense object. Since the average distances between neighboring galaxies are of the order of 10^6 light years, while their diameters are about 10^4 light years, it is easy to compute that within the diameter of the explorable universe—some 600 million light years—with its 10^8 separate

galaxies and 10^{52} cubic centimeters of stellar matter, there are approximately 10^{28} cubic centimeters of transparent space for every cubic centimeter of stellar matter. The average density of a star like the sun is a little greater than that of water. Hence the density of stellar matter in the universe is only about 10^{-28} g/cm^3. A density of the order of 10^{-15} g/cm^3 is considered a high vacuum in ordinary laboratory technique.

But the question arises whether all matter in the universe is concentrated in the form of stars. It is possible that free atoms and molecules or small particles of dust float in interstellar space without completely obstructing the light of distant stars and galaxies. Eddington once remarked that although astronomers do not know much about interstellar matter they talk a great deal about it; they are like the guest who refused to sleep in a "haunted" room and who, when asked whether he believed in ghosts, replied: "I do not *believe* in ghosts, but I am *afraid* of them." It is probably no exaggeration to say that interstellar matter was the ghost that has haunted astronomers for the past hundred years. Until about 15 years ago they steadfastly refused to believe that there existed any such matter, even though direct photographs of the Milky Way gave unmistakable evidence of large regions in space where the light of distant stars is more or less completely cut off by the screening effect of cosmic dust clouds. They were afraid of the ghost because they thought it would play havoc with their elaborate theories of the structure of the Milky Way. These theories all depended upon an application of the inverse square law for the brightnesses of the stars. If two stars are of the same intrinsic luminosity, for example, if both have spectra that exactly match the spectrum of the sun, but one star is of apparent magnitude 5 while the other is of apparent magnitude 10, then the astronomers reasoned that since each step in magnitude corresponds to a ratio of 2.5 in the brightnesses of the stars, the fainter star sends us one hundredth as much light as the brighter and that, consequently, its distance must be ten times greater than that of the brighter star. It is obvious that if a part of a star's light is intercepted by a screen of absorbing material, this computation would lead to erroneous results: the real distance of the faint star would be smaller than the one computed by means of the inverse-square law.

DISPERSION OF LIGHT IN SPACE

The first intimation of a possible effect of interstellar matter upon the propagation of light through cosmic space occurs in a letter by

Newton to Flamsteed, dated August 10, 1691. In the last sentence of this letter Newton, who was not an observer, asks the Astronomer Royal at Greenwich: "When you observe the eclipses of Jupiter's satellites I should be glad to know if in long telescopes the light of the satellite immediately before it disappears inclines either to red or blue, or becomes more ruddy or pale than before." The finite velocity of light had been measured in 1676 by Römer at Paris. He had used the predicted eclipses of the satellites of Jupiter and had taken advantage of the fact that Jupiter is at certain times much closer to the earth than at others. It was quite natural that Newton should try to find whether the velocity of blue and of red light is equal through interplanetary space, or whether an appreciable dispersion of the light takes place between Jupiter and the earth.

We have no record of Flamsteed's reply, and we do not even know whether observations were made to answer Newton's question. But astronomers gradually concluded that any possible dispersion was much too small to produce measurable effects in the satellites of Jupiter.

In 1855 Arago, in a course of public lectures at the Paris Observatory, applied the idea of Newton to the eclipses of distant binary stars whose orbit planes pass through the earth: "Let us then investigate what ought to be the density of this (hypothetical) interstellar gas in order that two rays, one red, the other blue, emitted at the same instant from a variable star, should arrive almost simultaneously at the earth notwithstanding the prodigious thickness of the matter traversed, notwithstanding the time of transmission which cannot be under three years; the solution of this simple problem of physics will astonish the imagination by its smallness." Arago gives no numerical results. He and others had "frequently examined periodic white stars in their different stages of brightness without remarking any appreciable coloring."

But these observations were made visually and were not very accurate. After the introduction of accurate photometric methods into astronomy, in 1908, it seemed for several years that a real positive effect of interstellar dispersion had been discovered independently by the Russian astronomer Tikhoff and the French astronomer Nordmann. These scientists found that when certain eclipsing variables are observed in red light the phase of central eclipse, or minimum light, occurs earlier than when the observations are made in blue light. For Algol (β Persei) the observed lag was 16 minutes $\pm$ 3 minutes. For λ Tauri it was 50 minutes and for RT Persei it was 4 minutes. This ap-

parent lag of blue light with respect to red light has been verified in many instances, and it is now known as the Tikhoff-Nordmann phenomenon. But, as Lebedeff had pointed out almost immediately after the announcement of Tikhoff's and Nordmann's discoveries, the distance of Algol is about 60 light years while that of RT Persei is 740 light years. Yet the nearer star has the longer lag of 16 minutes, so that if interstellar dispersion were responsible for the phenomenon the dispersion constant would have to be $16/4 \times 740/60 = 40$ times larger in the direction of Algol than in the direction of RT Persei. Modern determinations give somewhat different distances for the two stars, but the conclusion of Lebedeff has been shown to be true. Unless we make the absurd assumption that the dispersion constant is entirely different for different stars—even if they are located in the same part of the sky—the Tikhoff-Nordmann phenomenon must be due to some other cause.

The final word in the matter came from Shapley. For the stars of the globular cluster M5, whose distance is about 30,000 light years, or 3×10^{22} cm, blue light and yellow light arrived on the earth within an interval of -10 seconds $\pm$ 60 seconds. This corresponds to a difference of less than 0.3 cm/sec between blue and red light, and shows that the velocities are the same to at least one part in 10^{11}. We conclude that there is no measurable dispersion of light in interstellar space.

GENERAL ABSORPTION

Apparently the first astronomer to worry about the dimming of star light by intervening clouds of diffuse matter was Halley, around 1720. The argument was revived by Chéseaux in Switzerland, about 1744. Both astronomers pointed out that an infinite universe with an infinite number of self-luminous stars should cause the entire heavens to be ablaze with light —for no matter in which direction we should look, our line of vision would always ultimately reach the surface of some distant star. It was tacitly assumed that the distribution of the stars in space is uniform and that there are no dark stars. In 1823 the famous German astronomer Olbers expressed a similar view in the following words: "God has made the transparency of space imperfect in order to enable the inhabitants of the earth to study astronomy in its details . . . Without this, we should have no knowledge of the starry heavens; our own sun would be discovered only with difficulty by its spots; the moon and the planets would not be distinguishable, except as obscure discs upon a bright background, like the sun . . . " Fortunately all these dreadful consequences had been removed by the

foresight of the Creator who had introduced into interstellar space enough absorbing material to dim the light of the most distant stars so that the background is dark and not so brilliantly luminous as the sun.

It is futile now to speculate upon the scientific logic and the philosophical insight of these early astronomers. It is easy to see that even an infinite universe need not necessarily lead to a sky completely covered with stars, and the early arguments in favor of interstellar absorption are now, to say the least, unconvincing.

The mathematical theory of interstellar absorption was first precisely formulated by F. G. W. Struve, in Russia. His book *Études d'astronomie stellaire*, published in 1847, is the first really scientific study of the whole problem of interstellar matter. It forms the connecting link between the earlier semiphilosophical speculations of Olbers, Chéseaux, and Halley, and the brilliant theoretical researches of the last decades of the nineteenth century and the prewar years of the present century, principally by Seeliger, Kapteyn, and Schwarzschild. The common property of all these investigations was the tendency to smooth out the local irregularities in the observed structure of the Milky Way and to study an idealized or "typical" stellar system which retained certain characteristics of the Milky Way, such as galactic concentration, but purposely avoided the discussion of individual star clouds and dark regions.

Struve's work was based upon the star counts that Sir William Herschel had made with his giant telescopes in many different parts of the sky. These counts gave the numbers of all stars visible for every step in brightness, over a uniform field of the sky. The problem was to derive the true distribution of the stars in space and to find, if possible, whether there was an effect of absorption in space.

To consider this problem it is convenient to use the functions:

(1) $D(r)$—the density function, which measures the number of stars per unit volume, as a function of the distance from the sun, r.
(2) $\phi(M)$—the luminosity function, which measures the distribution of stars of different intrinsic luminosities
(3) $i = f(r)$—the intensity function, which measures the apparent brightness of a star as a function of its distance from the sun, r

The simplest assumptions that we can make and that we can test are

$$D(r) = \text{const} \; ; \; \phi(M) = \text{const} \; , f(r) = \frac{i_0}{r^2} \tag{1}$$

This is, essentially, what Olbers and his predecessors had assumed,

and it is fairly obvious that the appearance of the sky at once suggests one of two conclusions:

(*a*) the universe is finite, or

(*b*) there must be an appreciable absorption in space, in which case $f(r) \neq i_0/r^2$.

If we are not willing to abandon the inverse-square law, then it is easy to see that there must exist two simple, but important, statistical relations:

(1) The theoretical distances of stars of successive magnitude (apparent brightness) classes form a geometrical series whose coefficient is $(2.5)^{1/2}$

(2) The theoretical numbers of stars down to successive magnitude (apparent brightness) classes form a geometrical series whose coefficient is $(2.5)^{3/2}$

Since by definition the ratio of the observed intensities of two stars whose stellar magnitudes are m_1 and m_2 is

$$\frac{i_1}{i_2} = 2.5^{(m_1 - m_2)}$$

and since by (1)

$$\frac{i_1}{i_2} = \frac{r_2^2}{r_1^2}$$

we have the first relation; when $m_1 - m_2 = 1$

$$\frac{r_2}{r_1} = \sqrt{2.5} \tag{2}$$

Since, next, for uniform distribution of stars in space $(D(r) = \text{const.})$ the number of all stars down to each magnitude step is proportional to the volume of the spheres occupied by those stars which have the required apparent brightnesses, and since these volumes are proportional to r^3, we have, when $m_1 - m_2 = 1$:

$$\frac{N_2}{N_1} = (2.5)^{3/2} \tag{3}$$

or, for any value of $m - m_0$:

$$\log N_m = \log N_{m_0} + 0.6 \, (m - m_0) \tag{4}$$

Struve tested relation (4) by means of Herschel's star counts, which gave directly the values of N_m. There were large systematic departures in the sense that the observed N_m were smaller than those predicted

by the formula. Two possible conclusions presented themselves: (a) The assumption $D(r) = $ const. is wrong, and the density of the stars in space must decrease in all directions from the sun, or (b) the assumption $i = i_0/r^2$ is wrong, and there is an effect of interstellar absorption which makes i smaller than it would be without absorption. With regard to hypothesis (a), Struve writes: "Perhaps someone will say that there might be a gradual diminution in the star density in the principal plane, toward the outer boundaries of the Milky Way. But how much do we know concerning these boundaries? The Milky Way is for us absolutely impenetrable. What, then, is the probability that the sun should be located near the center of a disc whose extent is for us completely unknown? Let us recall, furthermore, that our study of the Herschel stars has led to the same average decrease in density, at right angles to the principal plane, which occurs in the neighborhood of the sun, up to the distance of stars of the 8th and 9th magnitude. From all these considerations I wish to state that we have discovered a phenomenon in which the extinction of star light unquestionably manifests itself." In place of the inverse-square law Struve adopts the relation

$$ i = \frac{i_0}{r^2} e^{-\lambda r} \tag{5} $$

where λ is the coefficient of absorption. This is equivalent, according to Struve, to a loss of one stellar magnitude per 3,000 light years, or $\lambda = 3 \times 10^{-4}$ if r is expressed in light years. This value, obtained almost 100 years ago, is amazingly accurate. Modern results give an average loss of light of between 0.7 and 0.8 stellar magnitude per kiloparsec (3,000 light years). The agreement is as good as between individual results of modern observers.

It is strange that Struve's results were not universally accepted. The tendency was to assume that $\lambda = 0$ and to derive the resulting function $D(r)$. This procedure was adopted by Seeliger, Kapteyn, Schwarzschild, and Charlier. It resulted in a badly distorted picture of the Milky Way, with the sun near the center and the star density decreasing in all directions. Halm, in 1917, attempted to find λ under the assumption $D(r) = $ const., but his results were not accepted. As late as in 1923, Kienle, after a careful review of all available evidence, concluded that the loss of star light through absorption must definitely be less than 2 mag/kiloparsec and that it is probably less than 0.1 mag/kiloparsec.[2]

[2] Mag is used in this paper as the abbreviation for stellar magnitude —EDITOR

The first definite break in astronomical opinion came in 1930 when R. Trumpler published his results on open star clusters, obtained at the Lick Observatory. His work was based upon measurements of the diameters of galactic star clusters—groups of tens or hundreds of stars forming compact systems in which the motions of the individual members are all alike. Typical among these formations are the Pleiades, the Hyades, the cluster in Coma Berenices, and others. By observing the spectra of the members of clusters and their brightnesses Trumpler was able to prepare for each cluster a Hertzsprung-Russell diagram, in which the brightness of each star appears as the ordinate and the spectral type as the abscissa. In a diagram of this kind, as Russell had found many years ago, the majority of the stars are arranged in a definite narrow band—the so-called main sequence. Physically speaking, the main sequence of one cluster should be rather similar to the main sequence of another. But since the distances of the two clusters are, in general, not the same, it is necessary to shift the diagrams along the vertical coordinate in order to make the two sequences coincide. This displacement, measured along the vertical coordinate in stellar magnitudes, provides a measure for the relative distances of the two clusters. Distances determined in this manner are affected by absorption. Suppose we find that the vertical shift corresponds to 3 magnitudes. This means that all stars of the brighter cluster are $(2\,5)^3 = 15.6$ times as intense as those of the fainter. If there were no absorption we should conclude from the inverse-square law that the fainter cluster is $\sqrt{15.6} = 3.95$ times as far away as the brighter cluster. But if absorption is present the real distance would be smaller. Trumpler conceived the idea of measuring the diameters of the clusters. He first made sure that he was measuring physically similar objects. If the brighter cluster had a diameter of 15' the fainter should have a diameter of $15/3.95 = 3'.8$ provided the distances inferred from the Hertzsprung-Russell diagram are correct. From a large amount of very homogeneous material Trumpler concluded that the diameters of the fainter clusters were systematically too large. He suggested that there is an appreciable amount of interstellar absorption and derived for it a value of 0.67 mag/kiloparsec.

Among the many modern determinations of the average amount of interstellar absorption per unit distance, one of the most interesting is due to Joy at the Mount Wilson Observatory. The method depends upon determinations of radial velocities of Cepheid variables and upon the theory of the rotation of our galaxy, which predicts that the rotational component of motion of a star in the line of sight must be pro-

portional to the distance from the sun. This results from the nature of galactic rotation in a central field of force. The matter is complicated by the fact that the stars have their own individual motions. But these are probably distributed at random so that if we take average velocities for groups of Cepheid variables arranged according to apparent magnitude we should derive a series of values the ratios of which, after correction for foreshortening, give us directly the ratios of the true distances for the various groups. Now, the Cepheid variables, as everyone knows, have the remarkable property that their periods of light variation are exactly related to their intrinsic luminosities, so that if we know the periods of two such variables we can tell at once how much brighter one is than the other. If we use this criterion of absolute luminosity, together with the apparent brightness, we derive the distance. If there were no absorption the two procedures should give identical results. From the departures, which are conspicuous, Joy, and later R. E. Wilson, derived an absorption of about 0.6 mag/kiloparsec.

Another method depends upon counts of extragalactic objects in different parts of the sky. These distant galaxies are seen through the thickness of absorbing matter in our Milky Way, and their numbers are greatest near the two poles of the galactic circle, while near the plane of the galaxy the absorption is so great that no outer galaxies are seen through it. In intermediate galactic latitudes the absorptions are proportional to the cosecants of the latitudes. For example, at galactic latitude 10° the absorption is 1.4 mag, at 20° it is 0.7 mag, at 30° it is 0.50 mag, at 60° it is 0.29 mag, and at 90° it is 0.25 mag. The smooth manner in which these values progress has suggested to Seares the idea that we are here dealing with "a widely diffused absorbing stratum extending equally above and below the galactic plane." The zone of complete avoidance of galaxies, which is irregular in shape, is associated by Seares with the obscuring clouds in the Milky Way which give their distinctive irregular appearance to the star clouds.

SELECTIVE ABSORPTION

In 1895 Kapteyn discovered that the average color of stars in the Milky Way is bluer than outside of it. He suggested that this phenomenon might be caused by selective absorption, which should make those stars appear bluer for which the absorption was least. Since at that time there was no conclusive evidence of general absorption, Kapteyn could not know that the color observations would be in disagreement with other evidence by requiring the absorption to be

greatest at the poles of our galaxy. In 1904 DeSitter made a careful study of star colors and concluded: "True differences in the colors of the stars, or general absorption in certain spectral regions, or selective absorption by intervening cosmical clouds or nebulous masses, these are questions that can be put, but not yet answered." We now know that the intrinsically blue, hot stars have a much greater tendency to concentrate toward the galactic equator than do the cool, red stars. Hence the phenomenon of Kapteyn has no bearing upon the question of selective scattering.

However, the question was revived some years later when Turner and others noticed that in order to obtain photographic star images of equal densities for successive stellar magnitudes, it was not sufficient to increase the exposure times in the ratio of 2.5 for each step of one magnitude. In fact, it was found that the ratio of the exposure times is much more nearly 3 than 2.5—in spite of the fact that by definition a step of one magnitude signifies an intensity ratio of 2.5. In other words, the photographic density B is not a function of the product $(i \times t)$ alone, where i is the light intensity and t is the exposure time, but may be written as

$$B = f(i \times t)^p$$

where $0 < p < 1$. The quantity p is now known as Schwarzschild's exponent.

Tikhoff and Turner suggested that p had a cosmic significance. They argued that selective absorption will make the stars appear redder the greater their distances. But distant stars are, on the average, faint. Hence, faint stars are red, and must require relatively longer exposures on the blue-sensitive photographic emulsions—the only ones then used for these observations. Turner summarized the matter in the following words: "The fact that when the photographic exposure is prolonged in a ratio which ought to give stars fainter by five magnitudes, we only get four visual magnitudes" is an argument in favor of "the scattering of light by small particles in space."

The obvious thing would have been to check the result by means of visual observations made with the help of violet filters. There is no reason why this could not have been done. The test would have shown at once that the fainter stars are not appreciably redder and that the Schwarzschild exponent is not a measure of interstellar reddening.

The correct interpretation of p was given in 1909 by Parkhurst. It represents a characteristic property of the photographic emulsion and determines what we now call the reciprocity failure of the emulsion. It is different for different brands of emulsions.

A new attack upon the problem became possible with the development of accurate methods of photographic photometry. Miss Maury at Harvard had remarked in her work on the spectra of the stars that among representatives of a single class of spectrum there were some which were weak in violet light while others were strong. Kapteyn examined the available data on star colors and found that within narrow groups of spectrum those stars which were rich in violet light had large angular proper motions, while those which had little violet light had, at the same time, small proper motions. Since the angular proper motion of a star is a good statistical measure of distance, he concluded that the distant stars are reddened by absorption. Unfortunately, this conclusion was incorrect. It turned out later that another interpretation could be given. The stars examined by Kapteyn within any given group of spectrum were, through observational selection, all more or less similar in apparent brightness. Hence, the distant stars of each group were giants, while the nearby stars were dwarfs. Kapteyn could not have known, or even suspected, that the surface gravities of the giants are very much smaller than those of the dwarfs and that, consequently, the pressures of the former are one hundredth as great as those of the latter. Equal spectral types imply equal average ionization. But in a giant with its low atmospheric pressure the same degree of ionization is attained at a lower temperature than in a dwarf. Kapteyn had discovered what is essentially the basis of spectroscopic luminosities, but he had not found evidence in favor of space reddening.

In 1923 Kienle could only conclude that the coefficient of selective absorption must be less than 0.1 mag/kiloparsec. As we shall see, this result was unnecessarily pessimistic. Even before Kienle's paper was printed, in 1919, Russell had called attention to the fact that "the three most abnormally yellow stars of type B (ζ, o and ξ Persei) lie within 5° of one another, in a region full of diffuse nebulosity," and he had suggested that this might be caused by local selective absorption in some of the dark clouds of the galaxy. Several years later Hertzsprung compiled a list of abnormally yellow B stars, whose color excesses were larger than can normally be explained as a result of differences in absolute magnitude. This list was greatly enlarged by Bottlinger, and in 1926 the present writer found fairly convincing evidence "that the effect of reddening . . . is produced by light scattering in dark nebulae or in calcium clouds."

The modern evidence concerning selective absorption in interstellar space rests upon three types of observation:

(1) Color excesses of B-type stars determined photoelectrically by Stebbins, Whitford, and Huffer, or photographically by Seyfert and Popper. These results show a progressive reddening for the more distant stars. In setting the 82-inch McDonald telescope upon a faint B-type star I have often been amazed at the redness of these stars: their continuous spectra show energy distributions corresponding to some 4,000° or 5,000°, while their absorption lines correspond to a temperature of 20,000°.

(2) Observations of color indices of members of open clusters by Trumpler and his associates.

(3) Determinations of the energy distributions and colors of stars involved in dense clouds of absorbing matter, by Seares and Hubble, Baade and Minkowski, Henyey, etc.

An important quantity is the ratio of selective absorption to total absorption. Seares concludes from a discussion of all available data that:

Total absorption $= 10 \times$ selective absorption, for the diffuse stratum of interstellar matter, and

Total absorption $= 5.7 \times$ selective absorption, for the dark nebulae of the zone of avoidance.

The latter law corresponds to an absorption coefficient which is proportional to λ^{-1}. The departure from Rayleigh's λ^{-4} law was first established by Trumpler, and was then confirmed by Struve, Keenan, and Hynek. It is probable that some stars, observed by Baade and Minkowski in the Orion nebula, present appreciable departures from the smooth λ^{-1} relation, but the exact nature of these departures has not yet been explored.

DIFFUSE RADIATION

The existence of reflection nebulae, whose spectra are continuous and whose absorption lines are identical with those of the associated stars was demonstrated many years ago by V. M. Slipher. Since that time the present writer, Henyey, Elvey, Greenstein, and others have investigated in detail the character of the diffuse light that is scattered by dark nebulae and by interstellar space. The light is nearly of the same color as that of the illuminating stars; in the Pleiades the nebulosity is slightly bluer, but the difference between nebula and star is much less than that between the blue sky and the sun. This is in agreement with the λ^{-1} relation found from the absorption effects. The diffuse light is very little polarized, which all goes to show that the particles are too large for Rayleigh scattering. On the other hand, there is some evidence to show that the phase function of the particles throws
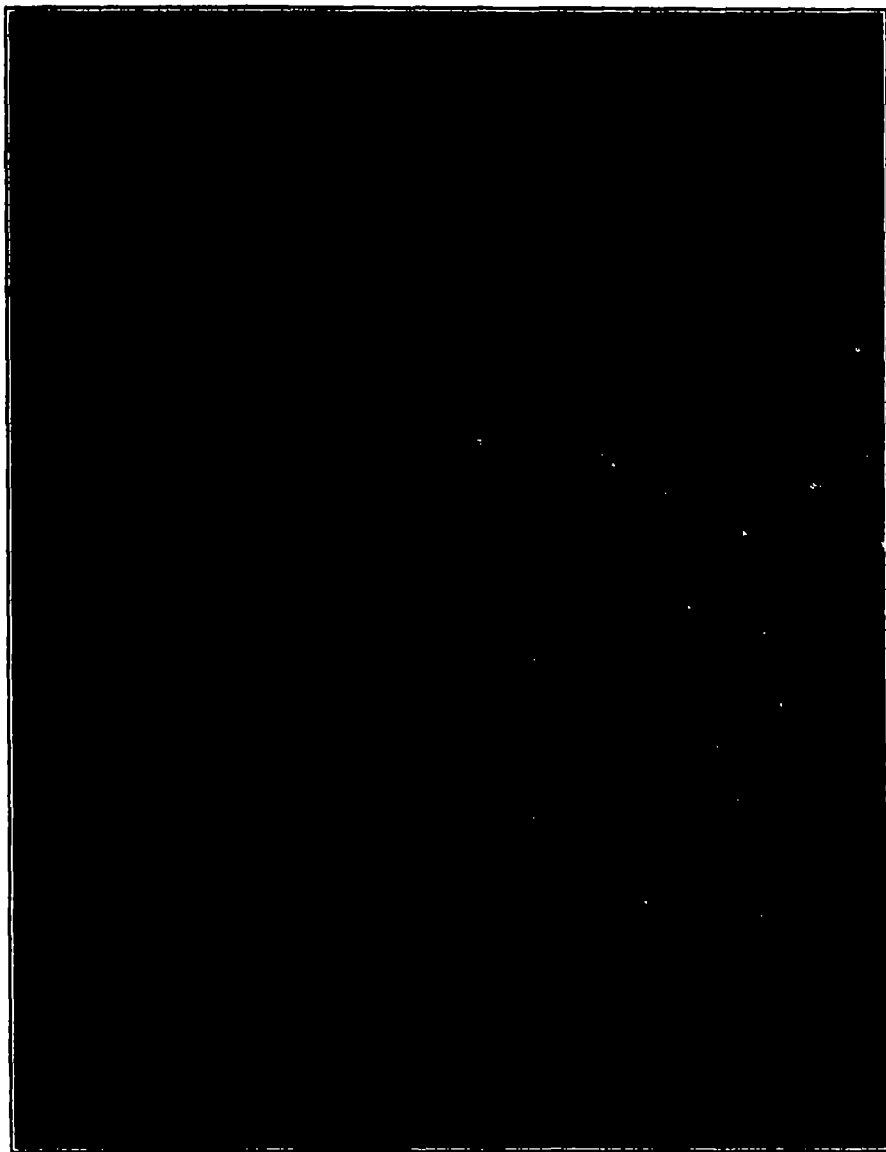
Fig 1 —Region in Taurus, showing obscuring nebulae that radiate feebly by reflecting the light of the stars.
(Photograph by E. E. Barnard)

most of the light forward and does not show the "phases of the moon," as one would expect if the particles were larger than about 0.01 cm in radius. This conclusion rests upon a comparison of the diffuse surface brightness of dark nebulae of absorbing matter. These nebulae are illuminated by the light of all stars around them. The situation is somewhat analogous to the case of a spherical body which is illuminated from all sides. If the intensity of the general starlight is assumed to be uniform and equal to $L_1 = 56$ stars of magnitude 10.0 per square degree, if γ is the albedo of the particles, α is the phase angle, i is the angle of incidence and ϵ the angle of emergence, then the surface brightness of the nebula is

$$I = \frac{\gamma}{2\pi} L_1 \int \phi(\alpha) \frac{\cos i}{\cos i + \cos \epsilon} \, d\omega. \tag{6}$$

This formula predicts that the rim of the nebula must be brighter than the center, but the amount of the difference depends upon the form of the phase function $\phi(\alpha)$. If we do not wish to make the albedo unreasonably large, we are compelled to adopt a forward throwing phase function. This suggests that the particles have radii smaller than 0.01 cm.

Sizes between 0.01 cm and 0.001 cm are excluded because of the absence of diffraction nebulosities surrounding stars that are seen through absorbing nebulosity. If the particles acted like water particles in clouds, of the required size, they should give rise to bright rings, which are often incorrectly called halos, the surface brightnesses of which may be computed. As a bright star seen through a thin cloud gives a halo, so the stars shining through dust clouds should produce halos. A search made by the writer some time ago yielded rather definite evidence that there is no halo formation. Hence the particles are smaller than 0.001 cm.

The interval of possible sizes for the majority of the particles has now been narrowed to between 10^{-3} and 10^{-5} cm. To go beyond this we must make use of the complicated theory of Mie for the scattering of light by small particles, and this has been done by a number of investigators, for example, by Shalén in Sweden and Greenstein in the United States. The most frequent sizes of the particles are slightly greater than 10^{-5} cm.

In connection with the problem of illumination of dense obscuring nebulosities, Struve and Elvey found in 1937 that the surface brightnesses of some of Barnard's dark nebulae are only about 0.03 mag fainter than the background of the sky between the stars in star
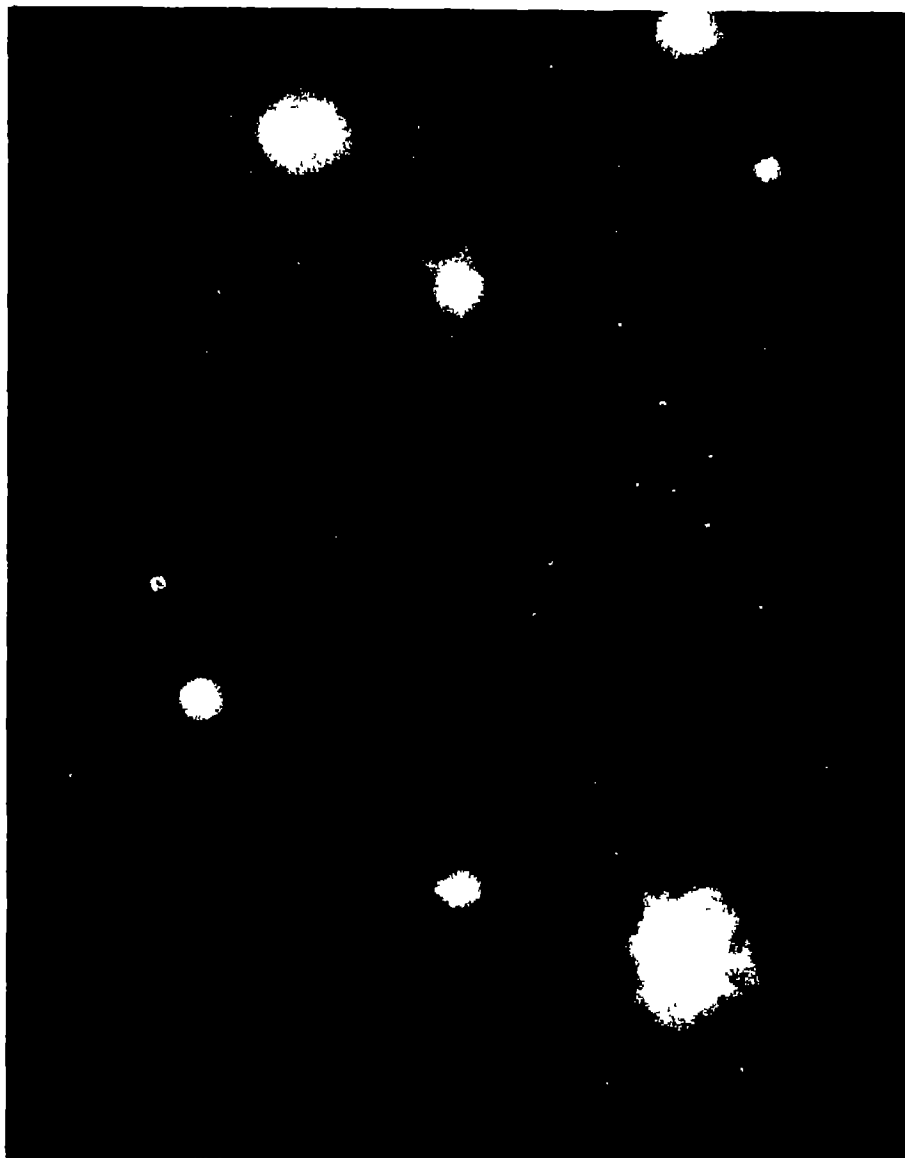
Fig 2 —Dark nebula projected upon luminous gaseous nebula, in Orion
(Photograph by J C Duncan)

clouds. If the star clouds were free of absorbing material the dark neb-
ulae should be considerably more luminous. Hence we conclude that
either the scattering efficiency (albedo) of the particles composing the
nebula is very low, or there exists a large amount of diffuse radiation
in the star clouds of the Milky Way. A direct observational test by

means of a photoelectric surface photometer was made by Elvey and Roach. They confirmed the correctness of the second alternative: there is a diffuse "galactic light" in the Milky Way, corresponding to about 57 stars of magnitude 10 per square degree, in the galactic plane. A careful study by Henyey and Greenstein has permitted them to subtract from the galactic light that part which comes from emission sources. In Cygnus, where the galactic light is strongest they find the diffuse radiation to be equivalent to 80 stars of magnitude 10 per square degree. In Taurus the galactic light is equivalent to only 35 stars of magnitude 10 per square degree.

Henyey and Greenstein consider the absorbing layer to be a slab of emitting and scattering matter, stratified along parallel planes. If the incident starlight and diffuse light has an intensity of L_1, each element of the absorbing material having an optical thickness $d\tau$, contributes to the observed galactic light the amount

$$\gamma d\tau \int L_1 \phi(\alpha) d\omega \qquad (7)$$

where γ is the albedo of the particles. The formula is analogous to (6). The total surface brightness of the galactic light in a given direction is obtained by multiplying (7) by $e^{-\tau}$ and integrating over τ from 0 to the limiting optical thickness of the absorbing layer τ_0:

$$I = \gamma \int_0^{\tau_0} e^{-\tau} d\tau \int L_1 \phi(\alpha) d\omega = \gamma(1 - e^{-\tau_0}) \int L_1 \phi(\alpha) d\omega. \qquad (8)$$

The quantity L_1 can be computed from star counts, provided we demand no refinements such as the variation of L_1 with τ. The phase function is not known. But it is clear that an isotropic distribution of the scattered radiation would make I larger than a strongly forward or backward throwing phase function. Indeed, at any given point on the slab of absorbing material the area of sky contributing to its illumination is greatest for $\alpha \sim 90°$. Hence a strongly forward throwing phase function will throw less radiation into the line of sight than an isotropic phase function. This presupposes that L_1 is uniform over the sky. In reality it is concentrated toward the Milky Way, and the integral must be evaluated numerically. In the region of Cygnus τ_0 must be very great. For all practical purposes we may assume that $\tau_0 = \infty$, so that

$$I_c = \gamma \int L_1 \phi(\alpha) d\omega. \qquad (9)$$

Knowing L_1 we can compute I for phase functions having different

tendencies of throwing the light forward. We need not consider backward throwing functions because we have already eliminated them.

For the Taurus region

$$I_T = \gamma(1 - e^{-\tau_0}) \int L_1 \phi(\alpha) d\omega \qquad (10)$$

Taking the ratio, we find

$$1 - e^{\tau_0} = \frac{I_T}{I_c} = \frac{35}{80} = 0\ 44 \qquad (11)$$

Since the integral $\int L_1 \phi(\alpha)\ d\omega$ is not strictly the same for the two regions Henyey and Greenstein derive a slightly different value. But we shall continue to use (11). Of course, τ_0 here refers to the Taurus region, where we evidently have relatively little material. In the Cygnus region the integral $\int L_1 \phi(\alpha)\ d\omega$ is about 72 stars of magnitude 10 in the case of an isotropic $\phi(\alpha)$; 80 stars of magnitude 10 for a moderately forward throwing ϕ; and about 135 stars of magnitude 10 for an extremely forward throwing ϕ. Since γ, the albedo, can not be greater than 1, we conclude that ·

   (1) the phase function must be at least moderately forward throwing, and

   (2) the albedo must be at least $80/135 = 0.6$.

Indeed, when $\gamma = 1$, we have

$$I_c = \int L_1 \phi(\alpha) d\omega$$

and this is true only when ϕ is moderately forward throwing. If $\gamma < 1$, then ϕ must be even more forward throwing. For an excessively forward throwing ϕ, when all radiation is thrown forward, the integral is 135, so that $I_c / \int L_1\ \phi(\alpha)\ d\omega = \gamma = 80/135 = 0.6$. If allowance is made for errors in the observations and for various refinements in the theory, Henyey and Greenstein find that the albedo must be greater than 0.3 and that the phase function must be strongly forward throwing.

<div align="center">STAR COUNTS</div>

Our knowledge of the absorptions in individual regions of the Milky Way rests now largely upon star counts. The method first successfully used by Wolf and later improved by Pannekoek has in recent years received a new impetus through the work of Bok and his star-counting bureau at Harvard. The method consists essentially in the comparison of star counts made in obscured regions with those made in open regions. If there were no dispersion in the luminosities of the stars the interpretation of the results would be simple. The exist-

ence of $\phi(M)$ causes considerable complications, but Bok has developed a numerical procedure which is particularly adapted to the study of individual dark nebulae. A list of these nebulae prepared by Greenstein and quoted by Bok is given in table 1.

TABLE 1 —ABSORBING CLOUDS

Region	Area in square degrees	Distance in parsecs	Diameter in parsecs	Absorption in magnitudes
Taurus–Orion–Auriga	600	145	65	1 1
Cepheus–Cassiopeia	450	500	170	0.7
Cygnus	85	700	130	1 5
Ophiuchus–Scorpius	1050	125	80	0 9
Vela .	105	600	120	1.0(?)

Shalén has used similar methods, but has limited the material to a narrow range of spectral type. Morgan and, quite recently, O'Keefe have made considerable progress by studying the spectroscopic luminosity criteria of B-type stars and by deriving the best possible individual distances for highly reddened stars.

DYNAMICAL CONSIDERATIONS

An indirect method of estimating the density of interstellar matter rests upon Oort's study of stellar motions at right angles to the plane of the Milky Way. The motions of the stars in the galactic plane are governed largely by the mass of the galactic nucleus. But the motions across the galactic plane are determined almost wholly by the distribution of mass in the vicinity of the sun. From the observed radial velocities Oort computes the space motions of the stars. The Z-components are then analyzed with regard to the distances of the stars from the galactic plane. This leads to a determination of the accelerations in the Z-coordinate, and these depend upon the density of matter in the vicinity of the sun. The data of observation are best satisfied for an average density of 0.092 solar mass per cubic parsec, which is equivalent to 6.3×10^{-24} g/cm^3. Oort finds that the luminous stars in the solar neighborhood account for 0.038 solar mass per cubic parsec. Hence, the difference, or 0.05 solar mass per cubic parsec, must be due to dark stars and to diffuse matter in interstellar space. This corresponds to a density of 3×10^{-24} g/cm^3—the famous Oort limit for the density of interstellar matter.

This leads to an estimate of the upper limit for the radius r of the particles. If the absorption were due to obscuration we would have for the absorption coefficient $n\pi r^2$, where n is the number of particles per cubic centimeter. With Trumpler's value of the absorption we write

$$2.5 \log_{10} e^{-n\pi r^2 l} = 0.7, \tag{12}$$

where l is equal to 3×10^{21} cm. Let the density of each particle be $d = 5$ g/cm^3. Then Oort's limit

$$3 \times 10^{-24} \text{ g/cm}^3 = n \frac{4}{3} \pi r^3 d. \tag{13}$$

Combining (12) and (13), we find

$$r = 10^{-2} \text{ cm}$$

This is an upper limit for the average radius of the particles and not an estimate of the sizes of those particles which are mostly responsible for the scattering of light.

INTERSTELLAR GASES

In 1904 Hartmann found that the absorption lines of Ca II in the spectrum of the double star δ Orionis fail to take part in the periodic oscillations of the other lines. He eliminated the obvious explanation that the stationary Ca II lines come from a very massive secondary component of the binary system and concluded that "at some point in space in the line of sight between the sun and δ Orionis there is a cloud which produces that absorption, and which recedes with a velocity of 16 km/sec." Since that time other atoms and molecules have been found to originate in interstellar space. Among them are Na I, Ca I, K I, Ti II, CN, and CH. Na I was found many years ago by Miss Heger at the Lick Observatory; Ca I, K I, and Ti II were found by Adams and Dunham; CH was measured by Dunham in 1937 and was identified by Swings and Rosenfeld; CN is due to Adams and McKellar. There are several unidentified absorption lines from interstellar matter. Among them are sharp lines at $\lambda\lambda$ 3957 and 4233.[1] These lines are very prominent in several B-type stars, for example ζ Ophiuchi, and are clearly of interstellar origin. There are also a number of diffuse absorption lines, or bands, discovered by Merrill and by Beals and Blanchet. They are as yet unidentified, but there is evidence that their intensities are closely correlated with color excess, so that they are perhaps produced by the dust particles. The wave lengths of these broad lines are $\lambda\lambda$ 4430, 5780, 5796, 6284, and 6614.

The remarkable thing about the identified lines is that they all originate from the lowest level of each atom. Even if the level is multiple, as in Ti II, only those numbers of the resonance multiplet appear which come from the lowest sublevel. Forbidden transitions depopu-

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[1] The symbols λ and $\lambda\lambda$ are used as abbreviations for "wave length" and "wave lengths," respectively; these wave lengths are expressed in Ångstrom units —EDITOR.

late the higher levels to such an extent that absorption lines originating in them are not seen.

One of the substances which might be expected to produce interstellar absorption lines is Fe I. Swings and I searched for it in the fall of 1939 on our spectrograms of early-type stars. The lowest level is a^5D and there are several lines of different multiplets which arise from it. We searched in B-type stars for the strongest expected lines, $\lambda\lambda$ 3719.94, 3440.63, and 3859.92. The first is in the wing of the hydrogen line H_{14} 3721.94. A search on Process plates taken with the quartz spectrograph of the McDonald Observatory for several stars in which interstellar Ca II is strong, for example ξ Persei, χ Aurigae, χ^2 Orionis, α Camelopardi, strongly suggests that λ 3720 is present. But the line is weak and we are not prepared to make a positive identification with the material now available to us.

The intensities and radial velocities of the interstellar lines of Ca II and Na I have been measured in many stars. There is a pronounced correlation between distance and intensity, first found by the present writer, which has served to give us an independent method for finding the distances of hot stars. The method has been discussed by a number of astronomers, some believe that the density of interstellar calcium or sodium is not sufficiently uniform throughout space to give reliable information regarding the distances. Dunham has even announced from measurements in α Virginis (distance 53 parsecs) and η Ursae Majoris (distance 66 parsecs) that "there is probably a region of lower than average density close to the sun." Dunham also thought that there was a difference in the average density of 2.4×10^{-10} ionized calcium atoms in the direction of α Virginis and that of 5.2×10^{-11} atoms in the direction of η Ursae Majoris. This latter conclusion depends upon the adopted distances of the stars, which may be somewhat in error, as Morgan has recently demonstrated. On the whole, it may be said that distances derived from the intensities of interstellar lines are fairly reliable, provided a correction is applied to take care of the concentration of the gas toward the galactic plane.

There is also a tolerably good correlation between line intensity and color excess. But each of these quantities is much better correlated with distance, so that we are certain that condensations of reddening particles are not necessarily accompanied by increased densities of interstellar atoms.

The radial velocities of the interstellar lines show (a) a relatively small tendency toward peculiar motions and (b) a conspicuous relation with galactic rotation, the line of sight component of the latter being

exactly one-half of its value derived from the corresponding stars. In view of the small peculiar motions the galactic rotation effect may be used for deriving the distances of the stars. However, there are numerous cases of stars showing double interstellar lines. These have been explained as being caused by two separate clouds of atoms, each having its own motion.

Whenever the star lines are broad and diffuse the attribution of a sharp line to interstellar matter is quite unambiguous. But when the star lines are sharp the distinction is not always easy, except in spectroscopic binaries. There has been in recent years too much of a tendency to take it for granted that all sharp Ca II lines in spectral types B3 and earlier are interstellar. I have recently measured the Ca II line λ 3933 in the luminous B1 star β Canis Majoris and have found on Texas Coudé plates that the line shares the oscillation of the star lines. Morgan has remarked that especially in supergiant stars the stellar calcium lines may sometimes persist as far as B0.

A problem of great interest and one that has not yet been completely solved is that of the line contours of the interstellar atomic lines. These contours are deep and become appreciably broadened in the more distant stars. It was at first suggested, by Unsöld, Struve, and Elvey, that the broadening may be caused by the effect of galactic rotation, and Eddington attempted to explain the relative intensities of Ca II to Na 1 as a result of the corresponding curves of growth. However, observations, principally by Merrill, Wilson, Sanford, and others at Mount Wilson, have shown that there are no striking differences in line contours of distant stars located (in galactic longitude) near the nodes and near the maxima or minima of the curve of galactic rotation. Clearly, near the nodes the broadening can not be due to galactic rotation, and in the absence of other Doppler effects, it must be due to the natural widening of the line by radiation damping. It is probable that a small effect of this kind does exist, but there can be no doubt that the lines in the two groups of stars are much more nearly alike than the theory predicts. Hence it may be regarded as certain that the contour is determined largely by turbulence, which masks the galactic rotation broadening except, perhaps, in the most distant objects. The average turbulent velocities have not been accurately determined, but they are probably of the order of 10 to 20 km/sec, in the line of sight.

THE IONIZATION PARADOX

In 1926 Eddington investigated the ionization of the interstellar gas. Since it is reasonable to suppose that the gas is in a steady state,

we write for the equilibrium of Ca I and Ca II:

$$\text{No. of ionizations} = \text{No. of recombinations} \tag{14}$$

or

$$\frac{\text{No. of bullets of quanta}}{\text{disrupting atoms}} = \frac{\text{No of ions colliding with electrons}}{\text{and forming atoms.}}$$

This is equivalent to:

$$\frac{N_1 \times \text{No. of quanta of}}{\text{appropriate power}} = \frac{N_2 N_e \times \text{function of cross sections for col-}}{\text{lisions and of velocity or temperature.}} \tag{14a}$$

In other words,

$$N_1 \phi(\text{Ioniz. pot.}, T) = N_2 N_e f(T, \sigma)$$

or

$$\frac{N_2}{N_1} N_e = F \ (\text{Ion Pot.}, T).$$

This is in effect Saha's ionization equation. In thermodynamic equilibrium it is

$$\log \frac{N_2}{N_1} N_e = - \chi \frac{5040}{T} + 1.5 \log T + 15.38 + \log \frac{2u_2}{u_1} \tag{15}$$

where χ is the ionization potential and u_2, u_1 are the statistical weights of the ground states of the ion and the atom, respectively. In the interstellar gas the radiation is very greatly diluted, and its spectral composition corresponds to the integrated effect of all the stars. In (14) or (14a) the left side is proportional to the density of the radiation and this is equal to Planck's function for the appropriate average temperature and to the dilution factor W, which measures the departure from thermodynamic equilibrium. W is equal to the ratio of the available density of radiation to that which would be available if for the appropriate temperature T there existed thermodynamic equilibrium. The right side of (14) or (14a) is not altered. We can, therefore, write the ionization equation for interstellar matter in the following manner:

$$\frac{N_2}{N_1} N_e = W \times F \ (\text{Ion. Pot.}, T),$$

or

$$\log \frac{N_2}{N_1} N_e = - \chi \frac{5040}{T} + 1.5 \log T + 15.38 + \log \frac{2u_2}{u_1} + \log W. \tag{16}$$

This, however, presupposes that the distribution of velocities of the electrons in the gas is Maxwellian and corresponds to the same tem-

perature T, as the one which results from the summation of the energy curves of all stars. This will not, in general, be the case. A more elaborate treatment for an electron temperature T_e gives

$$\log \frac{\dot{N_2}}{N_1} N_e = -x \frac{5040}{T} + 1.5 \, \log \, T + 0.5 \, \log \, \frac{T_e}{T} + \log W \quad (17)$$

Finally, in some applications of the theory it is necessary to allow for the gradual diminution of the ionizing radiation by absorption in the gas. This introduces an extra factor of $e^{-\tau}$ in the left side of (14) and (14a), so that our final expression is

$$\log \frac{N_2}{N_1} N_e = -x \frac{5040}{T} + 1.5 \log T + 0 \, 5 \log \frac{T_e}{T} + \log W + \log e^{-\tau}. \quad (18)$$

All logarithms are to the base of 10. The dilution factor can be determined from the observed distribution of the stars. Eddington proceeds in the following manner. He determines the appropriate temperature by summing the energy curves of all stars in the approximate wave length range where the ionization of calcium is produced. This turns out to be about 15,000°. In thermodynamic equilibrium Planck's formula gives an energy density of 387 erg/cm³ for 15,000°. In interstellar space conditions are different. We know that the sun radiates 3.8×10^{33} erg/sec and that a star of bolometric absolute magnitude 1.0 radiates 36 times as much, or 1.4×10^{35} erg/sec. By definition at a distance of 10 parsecs the absolute magnitude of a star is equal to its apparent magnitude. If we spread the energy radiated per second by our first magnitude star over a sphere of 10 parsecs in radius we have

$$\frac{1.4 \times 10^{35}}{4\pi \times 100 \times 9 \times 10^{38}} = 10^{-5} \text{ erg/cm}^2 \text{ sec.}$$

The energy density is obtained by dividing this by c. But the total of all star light is equivalent to 2,000 stars of the first apparent magnitude. Hence the radiation density in interstellar space is

$$\frac{2000 \times 10^{-5}}{3 \times 10^{10}} = 7 \times 10^{-13} \text{ erg/cm}^3$$

The dilution factor is

$$W = \frac{7 \times 10^{-13}}{387} = 2 \times 10^{-15}.$$

More accurate values have been derived by Gerasimovič and Struve, by Greenstein, and by Dunham.

We can now proceed and compute N_2/N_1 for Ca II/Ca I by substituting numerical values into (18). The question is what to use for N_e. Eddington determines a very rough value for the density of interstellar matter by assuming that the gaseous nebulae are condensations of the interstellar medium and that the theory of isothermal gas spheres may be applied to these objects. This gives $\rho = 10^{-24}$ g/cm^3. Since the electron pressure is not very different from the total gas pressure this estimate gives N_e and hence also N_2/N_1.

Gerasimovič and Struve proceeded in a different manner. In the absence of any information regarding N_e they assumed that all elements are equally effective in producing electrons in interstellar space, so that N_e could be determined from the equation

$$pN_e = N_2(\text{Ca}^+) + 2N_3(\text{Ca}^{++}),\qquad(19)$$

where $p = 0.015$ is the percentage abundance of calcium by atoms in the crust of the earth. This equation led to a very small value of N_e $= 10^{-3}$, which in turn gave a very high degree of ionization. The ionization of calcium and sodium derived by Gerasimovič and Struve is shown in table 2.

<div align="center">TABLE 2 —IONIZATION OF CALCIUM AND SODIUM
($N_e = 10^{-3}$)</div>

Calcium		Sodium	
Ca	3×10^{-11}	Na	2×10^{-7}
Ca$^+$	7×10^{-4}	Na$^+$	1
Ca^{++} .	1	Na^{++}	6×10^{-3}
Ca^{+++} .	2×10^{-4}	---	—

Since the observed line intensities of Na I and Ca II are very similar, the table suggests that in cosmic clouds sodium atoms must be 300 times more abundant than atoms of calcium. On the earth the abundance of sodium is only about 1.3 times that of calcium. This ratio is probably true of other cosmic sources, and it is strange that in interstellar space the abundance of sodium should be several hundred times greater. This result is similar to that of Eddington. It formed a serious barrier to further work.

<div align="center">SOLUTION OF THE PARADOX</div>

In 1926, when Eddington's work was published, and in 1929, when Gerasimovič and Struve published their computations, there was no reason to doubt that calcium was a very abundant substance. The fact that calcium and sodium were the only elements then known in the spectrum of interstellar matter, combined with the great inten-

sity of the calcium lines in the solar chromosphere and in prominences, led quite naturally to the idea of "calcium clouds," which were believed to consist largely of calcium. The idea advanced by Gerasimovič and Struve that the abundance of calcium might be only 1 or 2 percent was revolutionary in 1929.

However, later work on the composition of the sun by Russell a short time afterward established beyond doubt the tremendous preponderance of hydrogen over all other elements. Hence it became necessary to review the problem of the ionization of interstellar matter with the idea that hydrogen might supply the overwhelming majority of the free electrons.

The basis of the new discussion consists of Dunham's recent measurements of the intensities of the lines of Ca I 4226 and Ca II 3933 in several stars. From these intensities it is possible to derive the numbers of atoms per cm^2 of Ca^+ and of Ca, and thus determine by observation the ratio N_2/N_1. This was done independently by Struve and by Dunham. The ionization equation then leads directly to a determination of N_e. Struve finds 30; Dunham obtains values of 14.4 and 7.3, depending upon which of two assumptions he uses for the integrated ultraviolet radiation of all stars. Within the past few days we have received a communication from Bates and Massey, of Northern Ireland, who have corrected the ionization formula (18) for the fact that the ionization processes take place almost exclusively from the ground level of the Ca atom, while in recombination many atoms first find themselves in higher energy states, from which they rapidly cascade downward to the ground level. This correction effectively reduces the ionization so that the same observed ratio N_2/N_1 can now occur at a lower electron density N_e. The factor is approximately equal to 6. Taking Dunham's upper value, 14.4, we find.

$$N_e = 2\,4 \text{ cm}^{-3}. \tag{20}$$

We shall see in the next section that there is a good confirmation of this value from observations of interstellar hydrogen emission lines. The uncorrected value of N_e is sufficient, as I pointed out in 1939, to greatly improve the Na/Ca paradox. Using this N_e, and adjusting W and T for the required ionization potentials, we compute:

$$\left.\begin{array}{ll} \dfrac{N_2(Ca^+)}{N_1(Ca)} = 100 \quad \text{and} \quad & \dfrac{N_3(Ca^{++})}{N_2(Ca^+)} = 10 \\[3mm] \dfrac{N_2(Na^+)}{N_1(Na)} = 270, & \dfrac{N_3(Na^{++})}{N_2(Na^+)} = 0 \end{array}\right\} \tag{21}$$

From the equivalent widths of Ca K and Na D and the corresponding distances, Wilson and Merrill found

$$N_1(\text{Na}) = 3 \times 10^{-9} \text{ cm}^{-3}, \tag{22}$$

while for Ca K, Merrill and Sanford found

$$N_2(\text{Ca}^+) = 9 \times 10^{-9} \text{ cm}^{-3} \tag{23}$$

Combining (21) with (22) and (23) we obtain the total numbers of sodium and calcium atoms.

$$\left.\begin{array}{r}N_1(\text{Na}) + N_2(\text{Na}^+) = 8 \times 10^{-7} \text{ cm}^{-3} \\ N_1(\text{Ca}) + N_2(\text{Ca}^+) + N_3(\text{Ca}^{++}) = 1\ 2 \times 10^{-7}\text{ cm}^{-3}\end{array}\right\} \tag{24}$$

Sodium is about 7 times as abundant as calcium. Dunham finds a larger ratio,

$$\frac{\text{Na}}{\text{Ca}} = 25, \tag{25}$$

but even this is very much better than the discrepancy of 300 found in the earlier work. Stromgren suggests that the small remaining inconsistency of (25) with terrestrial data will disappear when the correction of Bates and Massey is applied to Na, as well as to Ca. Since the theory is difficult, expecially in not being able to give us very reliable values of T and W, we may consider the paradox of the ionizations as having been eliminated. Moreover, we must remember that the determinations in (22) and (23) rest upon the curves of growth for Ca and Na, and these are still incompletely known. Finally, the distances of the B stars are not accurately known.

INTERSTELLAR HYDROGEN EMISSION

We have already expressed the suspicion that the large value of N, may come from the ionization of interstellar hydrogen. Consider the ionization of hydrogen. If we disregard the factor e^{-r} in (18) and set $T_s = T$, we find with the appropriate values at $\lambda = 900$ A, viz. $T = 25,000°$, and $W = 10^{-17}$

$$\frac{N_2(\text{H}^+)}{N_1(\text{H})} \approx 10 \tag{26}$$

Since W and T are uncertain, this value is only a rough approximation.

The only lines of hydrogen which are accessible to observation are those of the Balmer series. Let us see how many H atoms we must

have in order to account for the value of N_e which we have derived from the calcium absorption lines. For simplicity let us use not the final result (20) but a value which is close to that derived by Dunham, namely

$$N_e = 10 \text{ cm}^{-3}.$$

Evidently, since $N_e = N_3(\text{H}^+)$ we conclude from (26) that we have in space one neutral atom of H per cm³. The question arises whether there is any chance of observing the bright H line in interstellar space.

We first compute the numbers of atoms in the third quantum level. Since this level is not metastable the population is proportional to W, so that

$$\frac{n_3}{n_1} = W e^{-(h\nu/kT)} \tag{27}$$

With $W = 10^{17}$ and $e^{-h\nu/kT} = 10^{-2}$ we have

$$n_3 = 10^{19} \text{ cm}^3. \tag{28}$$

Consider now the depths of space Our Milky Way extends to tens of thousands of parsecs from the sun, but in effect the more distant regions are cut off by obscuring nebulosities. We can make only a rough guess as to the effective thickness of the visible layer:

$$D = 1,000 \text{ light years} = 10^{21} \text{ cm}. \tag{29}$$

Hence we shall have

$$n_3 D - 10^2 \text{ atoms/cm}^2 \tag{30}$$

The question arises· Can the emission of 100 hydrogen atoms per cm² be observed? The energy emitted by the layer is

$$n_3 D h\nu A_{31}$$

where $h\nu = 0.5 \times 10^{-11}$, $A_{31} = 0.5 \times 10^8$, and $n_3 D = 100$. This is

$$n_3 D h\nu A_{31} \approx 10^{-2} \text{ erg/cm}^2 \text{ sec}$$

This is considerably brighter than the limit of human vision for surface brightnesses. The latter is roughly equivalent to one star of magnitude 9 per square degree. Since the apparent magnitude of the sun is -26, and since it covers about one-fifth of a square degree this means that we can detect surface brightnesses which are 35 magnitudes or about 10^{14} times as faint. The total radiation of the sun is about 10^{11} erg/cm² sec. Our eyes are sensitive to only a fraction of this, let us say to $\frac{1}{3}$. Hence the minimum surface brightness we can see is

$$\frac{2 \times 10^{10}}{10^{14}} = 2 \times 10^{-4} \text{ erg/cm}^2 \text{ sec.}$$

This is a fiftieth as faint as the expected brightness of the interstellar hydrogen emission. There is all reason to search for it. This was done a few years ago at the McDonald Observatory, with a specially constructed nebular spectrograph of great efficiency. The instrument consists of a narrow plane mirror, which acts as the slit. The light from the sky is reflected by the slit-mirror along the direction of the polar axis. At a distance of 75 feet it is intercepted by a plane mirror and returned to the prism box and f/1 Schmidt camera. Each spectrum is accompanied by a comparison spectrum from some other part of the sky.
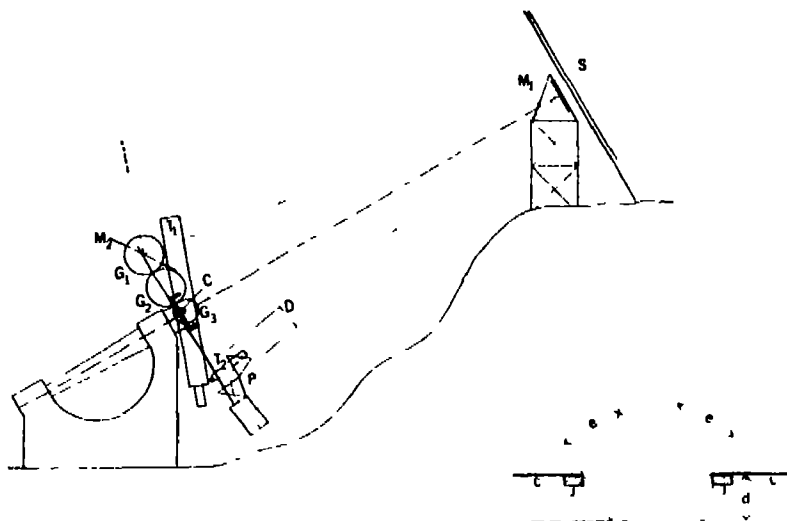
Fig 3 —Nebular spectrograph of the McDonald Observatory M_2 = narrow plane mirror acting as slit, M_1 = stationary plane mirror, P = prisms over camera; T = guiding telescope

The results of the observations numbering nearly 80 long exposures show that —

(1) There are large regions in the Milky Way where H, [O II] 3727, [N II] 6548, 6484, and occasionally [O III] N_1 and N_2 appear in emission.

(2) These nebulae show but little concentration toward individual early-type stars, thereby differing conspicuously from ordinary gaseous nebulae.

(3) There is no emission at high galactic latitudes.

(4) The emission regions of H in Cygnus, Cepheus, and Monoceros are fairly sharply bounded on the outside. They are roughly circular

Fig 4 —Nebular spectrograph of the McDonald Observatory

in appearance. The intensity drops somewhat from the inner parts of each region toward the outer boundary, but this variation is relatively small.

(5) Whenever [O III] is seen in emission, it occurs in the central parts of the II regions, without any sharp boundaries.
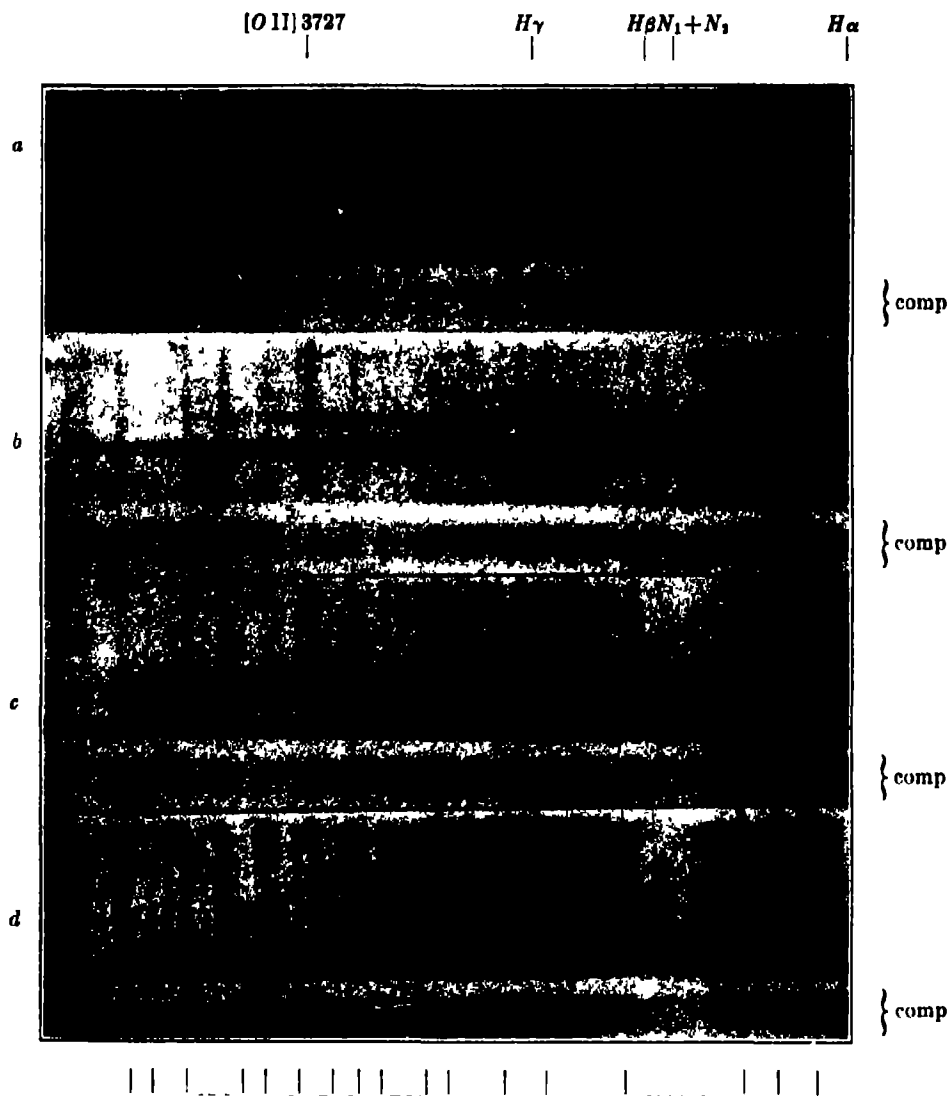
AURORAL LINES

(a) Guiding star 56° 2604 Nebula IC 1396
(b) Guiding star 60° 504 Loose cluster
(c) Guiding star 59° 559 Loose cluster
(d) Guided 6′ south of 29° 741

Fig. 5 - -Spectra of Milky Way regions showing emission of H, [O II]
and [O III] superimposed over spectrum of night sky

(6) The H regions are probably associated with groups of O-type stars. This is demonstrated in Figs. 7 and 8 where the spectroscopic results are shown at the top, the distribution of the O stars at the bottom. The emission regions are shown by solid circles. Absence of emission is denoted by open circles.

Fig 6 —Milky Way in Cygnus A large part of this area covering nearly 400 square degrees shows emission lines of H and [O II]

(7) The ratio in intensity [O II]/(H+[N II]) is large in Monoceros and Canis Major and small in Cygnus, Cepheus, and Sagittarius. This effect demonstrates a conspicuous difference between the physical conditions of the emission regions in two different parts of the sky.

(8) Some of the emission regions show a slightly milky background on the direct photographs of Ross and Barnard, but there are other regions of similar milky appearance which shine by reflected light.

(9) The hydrogen emission regions sometimes cover dark markings while in other instances the emission does not seem to extend over the

dark nebulosities. In the Taurus region there is no emission in the dark clouds, except in the immediate vicinity of bright O and early B stars. In the Ophiuchus nebulosities emission is seen only near the B1 star σ Scorpii. The other bright stars, of type B3, produce only reflection nebulae.

(10) Slipher reports that in the region $\alpha = 18^h\ 8^m$, $\delta = -18°\ 16'$ the emission of H covers not only the star cloud, but also the dark marking B92.

The sizes of the emission regions are of the order of $s_0 = 7°$ for the one around λ Orionis and $s_0 = 5°$ for the one in Cygnus. Assuming reasonable absolute magnitudes for the associated O stars we find the following linear dimensions:

Region	Radius
near λ Orionis	40 parsecs
Cygnus	130 parsecs
Monoceros	85 parsecs

The intensities of the observed hydrogen lines may be used to compute the number of atoms per cm^3 in the third energy level. In principle this is simple and can be done by reversing the procedure of the first part of this section. In practice there are many difficulties because we are dealing with an extremely faint light source. A fairly good average result from two independent series of observations is

$$n_3 = 5\ cm^{-2}.$$

Assuming $s_0 = 300$ parsecs (for which we shall see the justification later)

$$N_3 = \frac{5}{3 \times 10^2 \times 3 \times 10^{18}} = 5 \times 10^{-21}\ cm^{-3}. \tag{31}$$

We next apply the formula

$$\frac{N_3}{N_1} = \frac{g_3}{g_1}\ W e^{-(h\nu/kT)},$$

which gives

$$N_1 = 3 \times 10^{-2}\ cm^{-3}.$$

Allowing for the ionization, as in (26):

$$\frac{N_2(H^+)}{N_1(H)} = 6,$$

we have
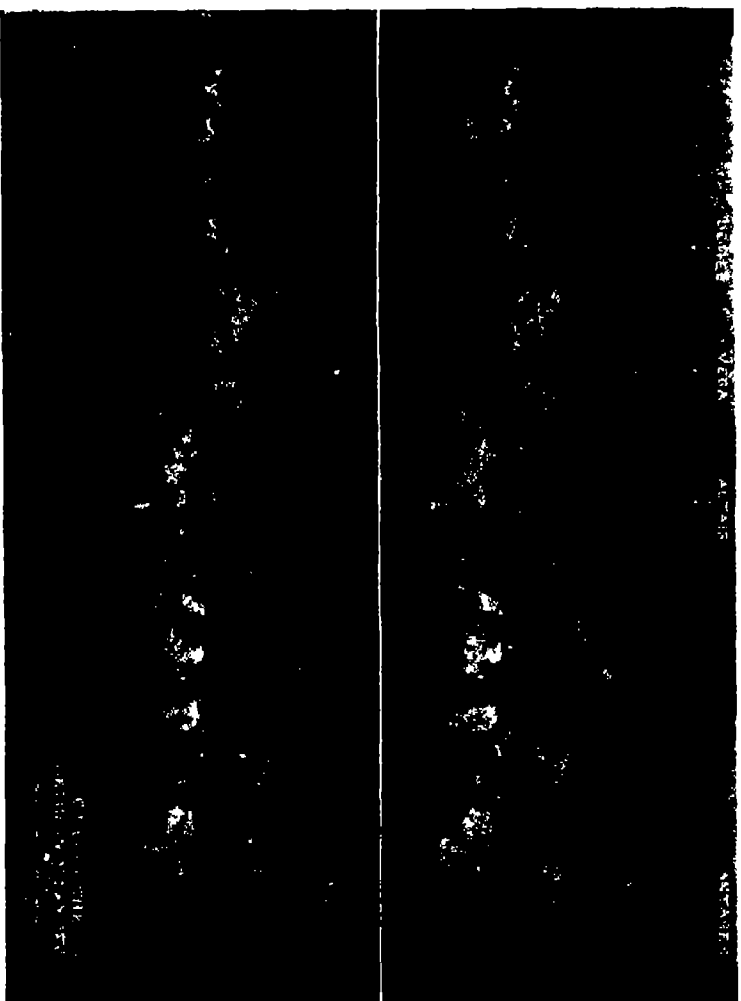
Fig. 7.—Summer Milky Way. At the top, regions showing emission of H and [O II] are plotted as solid circles. At the bottom, the known stars of spectral type O are plotted as open circles. The composite map was made by Miss Mary R. Calvert from the Atlas of the Milky Way by F. E. Ross and Mary R. Calvert.
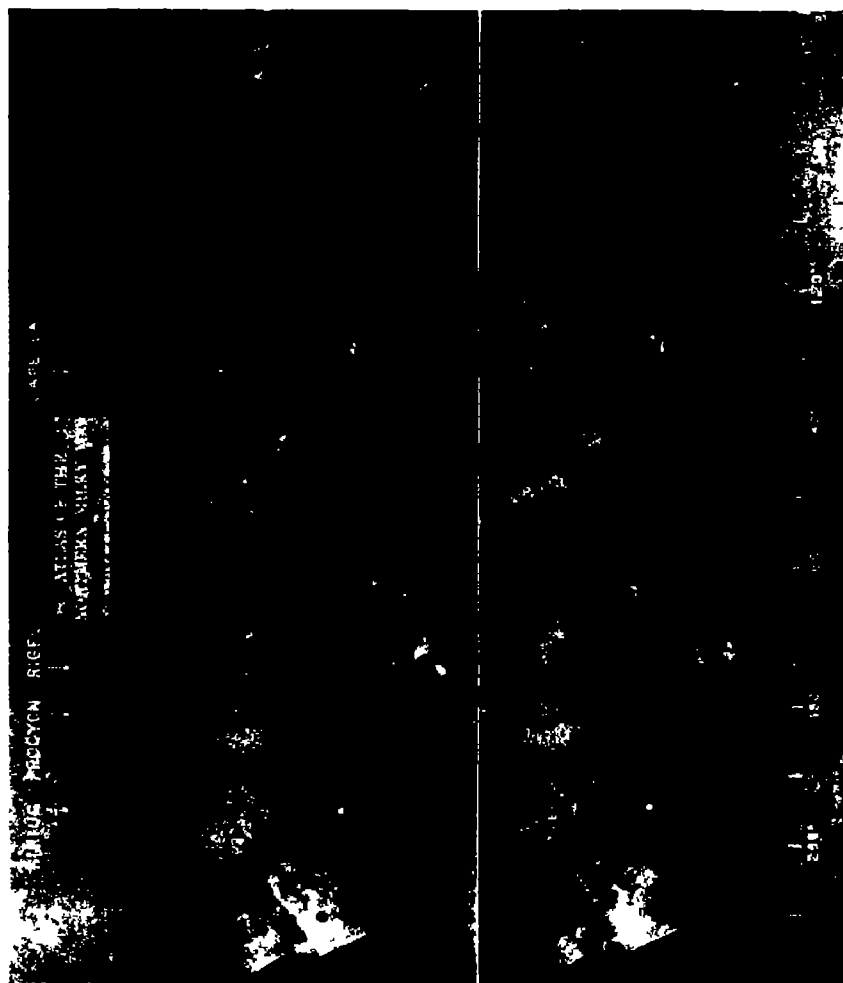
Fig 8—Winter Milky Way At the top, regions showing emission of H and [O II] are plotted as solid circles, regions without emission are plotted as open circles At the bottom the known stars of spectral type O are plotted as open circles

$$N_2(\mathrm{H}^+) = 0.2 \ \mathrm{cm}^{-3}.$$

But we should not have used the three-state problem. Evidently several other H levels will contain approximately the same populations as the third level. In fact, the second level may even be overpopulated. Strömgren has allowed for this effect accurately, but we shall simply estimate that the error due to the neglect of other excited levels corresponds to a factor of 10. Then the total number of hydrogen atoms is:

$$N_1 \approx N_\bullet \approx N(\mathrm{H}) = 2 \ \mathrm{cm}^{-3}.$$

From his detailed analysis which is based upon my and Elvey's observational data Strömgren finds

$$N(\mathrm{H}) = N_\bullet = 3 \ \mathrm{cm}^{-3}. \tag{32}$$

This agrees closely with the value derived from calcium.

STRÖMGREN'S THEORY

The significant element of this theory is the retention of the term $e^{-\tau}$ in the ionization formula (18):

$$\frac{N_2(\mathrm{H}^+)}{N_1(\mathrm{H})} N_\bullet = C \times \frac{1}{s^2} e^{-\tau}, \tag{33}$$

because $W = R^2/4s^2$. The constant C involves the ionization potential of H, the temperatures T and $T_\bullet$ and the radius of the exciting star R. Since presumably almost all free electrons came from H

$$N_\bullet = N_2(\mathrm{H}^+). \tag{34}$$

The optical depth τ is measured near the limit of the Lyman series:

$$d\tau = N_1(\mathrm{H})a_u ds, \tag{35}$$

where a_u is the continuous absorption coefficient near λ 900 per neutral hydrogen atom. This quantity is known. In our ionization equation

$$\frac{[N_2(\mathrm{H}^+)]^2}{N_1(\mathrm{H})} = C \times \frac{1}{s^2} e^{-\tau} \tag{36}$$

the ionization decreases with increasing distance from the ionizing star. Since a_u is small this decrease is at first mainly caused by $1/s^2$, because for small s, the factor $e^{-\tau}$ is close to 1. But as the distance increases $e^{-\tau}$ becomes more important. Because of the exponential it causes a very abrupt change in ionization, producing a sharp bound-

ary beyond which H is almost completely neutral and inside of which it is almost entirely ionized. The radius of this boundary, s_0, can be computed. It depends upon the temperature and radius of the ionizing star and upon the density of hydrogen, $N(H) = 3$ cm^{-3}. Physically what happens is this: "In the immediate neighborhood of a star, interstellar hydrogen will be ionized. With increasing distance from the star the proportion of neutral hydrogen atoms increases, and hence the absorption of the ionizing radiation increases. Ultimately, the ionizing radiation is so much reduced that the interstellar hydrogen is un-ionized." Table 3 gives the quantity N_2/N_1+N_2 for several values of the ratio s/s_0.

TABLE 3 —IONIZATION OF HYDROGEN AS A FUNCTION OF DISTANCE

s/s_0	$\dfrac{N_2}{N_1+N_2}$
0 00	1 00
0 58	1 00
0 74	0 99
0 84	0 98
0 93	0 96
0 97	0 94
1 00	0 85
1 03	0 33

The very rapid decrease of N_2/N_1+N_2 near $s/s_0 = 1$ is of fundamental importance. It shows that each star is surrounded by a sharply limited volume of space where H is almost wholly ionized, while outside of this volume H is un-ionized.

Table 4 gives Strömgren's computations for the radius s_0 of the ionized hydrogen region, as a function of spectral type. The computation is based upon values of the radii corresponding to main-sequence stars.

TABLE 4 —RADII OF REGIONS OF IONIZED HYDROGEN

Spectrum	T	Vis. Abs. Mag.	s_0 in parsecs	s_0 in parsecs for main sequence and $N=3$ cm^{-3}
O5	79,000°	−4 2	$54 \times R^{3/2} N^{-1/2}$	67
O6	63,000	−4 1	40	52
O7	50,000	−4 0	29	41
O8	40,000	−3 9	20	31
O9	32,000	−3 6	13	22
B0	25,000	−3 1	7 2	12
B1	23,000	−2 5	5.6	8
B2	20,000	−1 8	4.2	5
B3	18,600	−1 2	3.1	3
B4	17,000	−1 0	2 2	2
B5	15,500	−0 8	1 6	1 8
A0	10,700	+0.9	1	0.2

The table illustrates the great preponderance of the hot stars in creating volumes of ionized hydrogen. In the regions of ionized hydrogen the Balmer lines will be excited by several mechanisms and will give rise to emission lines. Stromgren identifies these regions with the extended areas of hydrogen emission found in the McDonald Observatory survey of the Milky Way. In these areas O stars are abundant. For a group of n stars the radius s_0 increases as $n^{1/3}$, so that from Table 4 we infer that a group of 10 or 15 late O stars would create an ionized sphere of about 300 parsecs in diameter. This is of same order of size as the observed region in Cygnus (p. 248). In the un-ionized regions nearly all the radiation beyond the Lyman limit, and also that in the Lyman lines L_β, L_γ, etc. has been converted into L_α and low-frequency lines. There will be almost no excitation of the third and higher levels of hydrogen, but the second level may be superexcited by a factor of 10^3.

It is of interest to consider the manner in which the radius of the ionized region depends upon the various quantities involved. In this connection it is important to remember that the discussion applies only to an element which furnishes the vast majority of free electrons. In the ionized regions this is hydrogen, and within these regions the ionization of elements of higher ionization potential is not influenced by a term of the form e^{-r}. Stromgren derives for s_0, when $T_e = T$:

$$\log_{10} s_0 = -5\,85 - \tfrac{1}{3} \log a_u^{-} - \tfrac{1}{3}\theta I + \tfrac{1}{2} \log T + \tfrac{2}{3} \log R - \tfrac{2}{3} \log N,$$

where

$$I = \text{ionization potential;} \quad \theta = \frac{5040}{T}, \quad a_u = 6\,3 \times 10^{-18}\ \text{cm}^{-2}.$$

But

$$\log R = \frac{5900}{T} - 0\,20\,M_v - 0\,02.$$

Hence

$$\log_{10} s_0 = -5.85 - \tfrac{1}{3}\log a_u + (3900 - 1660\ I)\,\frac{1}{T} + \tfrac{1}{2} \log T - 0\,13\,M_v - \tfrac{2}{3} \log N.$$

Clearly s_0 is very sensitive to T, because of the term $(3900 - 1660 I)$ $1/T$. Except when I is small, $1660\ I/T$ predominates. For example,

when $I = 10$ volts,	$T = 8{,}300$;	$s_0 = 1$
" $I = 10$ "	$T = 16{,}600$	$s_0 = 10$
" $I = 50$ "	$T = 8{,}300$	$s_0 = 1$
" $I = 50$ "	$T = 16{,}600$	$s_0 = 10^5$

The conclusion is that when I is large hot stars alone are important.

The effect of M_* is relatively slight, because of the coefficient 0.13. For a main-sequence star and a supergiant of class A we have

$$\text{main sequence}\quad A0 : M = +0.9$$
$$cA0 : M = -6.0$$

The value of $\log_{10} s_0$ changes by $0.13 \times 6.9 = 0.9$. If for a main-sequence A0 star Table 4 gives $s_0 = 0.2$ parsec, the supergiant will give $s_0 = 16$ parsecs. This is of the order of size required for α Cygni which may be responsible for the luminosity of the North America nebula and the surrounding emission region. The distance is about 200 parsecs and the apparent radius $s_0 = 4°$. This gives $s_0 = 14$ parsecs, which is close to the value derived from Stromgren's theory.

In the case of γ Cygni, which is of type F8 and which is believed to be responsible for some faint hydrogen emission showing a symmetric arrangement around this star, the agreement is poor. The distance is about 140 parsecs and $s_0 = 4°$. Hence the radius should be $s_0 = 10$ parsecs. But the temperature is much lower than that of α Cygni. It is difficult to see how γ Cygni can be responsible for the emission region unless it radiates at $\lambda 900$ like a late B star. The importance of supergiants may become appreciable in the case of early class B.

Let us next apply the theory to two relatively close O stars, γ Velorum and ζ Puppis. For these stars

$$M_* \approx -4$$

and

$$D \approx 200 \text{ parsecs.}$$

For type O8 Table 4 gives $s_0 = 31$ parsecs. Hence we are well outside the ionized regions surrounding these two stars. Observations confirm this· there is no emission at high galactic latitudes.

EMISSION OF FORBIDDEN OXYGEN

The McDonald Observatory results show the following:

(1) [O II] is nearly always present in the regions of ionized H.

(2) There is a relative strengthening of [O II] in the winter Milky Way and a weakening in the summer Milky Way.

(3) The regions of [O II] coincide with those of H and have the same sharp boundaries.

(4) [O III] is rarely observed, but when it does occur it is limited to the inner parts of the H regions, and it shows no sharp boundaries.

(5) [O I] was never observed, although a special effort was made to distinguish it from the strong auroral lines in the spectrum of the night sky.

These results are in good agreement with Stromgren's theory. Since N_e depends on H, the decrease of [O III]-intensity is caused by the term $1/s^2$. The same is true for [O II]; at the boundary of H the ionization of O will also suddenly stop. Since all exciting stellar radiation is cut off at s_0, elements of ionization potential higher than that of H, 13.54 volts, are un-ionized. This applies to the following:

O	I P. = 13 56 volts
O+	34 94
O++	54 88
He	24 48
C+	24.28
N	14 49

Elements of lower ionization potential may be ionized in the regions where H is neutral. This applies to

C	I P. = 11 22 volts
Ca	6 09
Ca+	11 82
Na	5 11

Carbon is probably the most abundant of these elements and it must be the source of the free electrons in these regions. Allowing for the low abundance of C with respect to H, we estimate that in the non-hydrogen regions N_e is between 10^{-2} and 10^{-3} cm^{-3}. It will be recalled that this is very similar to the value originally inferred by Gerasimovič and Struve for interstellar space. Hence conditions of ionization for Ca and Na in the nonhydrogen regions must be approximately those which they had derived. This means that Ca is nearly all doubly ionized, so that if we observe a star through a series of hydrogen and nonhydrogen regions, it is the former that give most of the absorption within the stationary lines of Ca II.

Na I is even more reduced in the nonhydrogen regions and Ca I originates almost entirely in the regions of ionized hydrogen.

It is not at once obvious why [O I] is not observed outside the regions of ionized hydrogen. It is certainly not ionized, because the ionization potential of O almost coincides with that of H. The forbidden lines of [O I] are also weak in planetaries. There we could make the plausible assumption that the gas ceases to exist in the ring in which we should otherwise expect [O I] to be strong. But this does not help in the case of interstellar space. Provisionally it seems possible that because of the low electron density in the nonhydrogen

regions there are not enough collisions to excite the metastable levels of O I. Since the high levels are probably not appreciably excited by radiation and since there is no ionization, recombination and cascading can not help to populate the metastable levels. We are compelled to assume that excitations by electron collisions are not sufficiently numerous to produce the forbidden lines.

It is of some interest to compute the abundance of O from the observed intensities of the line $\lambda 3727$. The observational data give us n_2, the number of atoms per cm^2 in the upper, metastable level:

$$\log n_2 = 11\ 97.$$

This is very large compared to hydrogen, because of the metastability of the term. We can now apply two methods of reasoning in order to determine n_1. (1) excitation by pure radiation and (2) excitation by collisions.

Method (1) depends upon the formula for the three-state problem, with the second level assumed to be metastable:

$$\frac{n_2}{n_1} = W \cdot \frac{A_{32}}{2A_{21}} \rho_{13}$$

where

$$\rho_{13} = e^{(h\nu_{13}/kT)}$$

Using $T = 25,000°$, $W = 10^{-17}$ we have $\rho_{13} = 10^{-4}$. Since $A_{32} = 10^8$ sec^{-1}; $A_{21} = 2.4 \times 10^{-5}$ sec^{-1}, we have

$$n_2/n_1 = 2 \times 10^{-9}.$$

$$n_1 = 5 \times 10^{20}$$

If $s_0 = 300$ parsecs $= 10^{21}$ cm, we find

$$N_1 \approx 10^{-1} \text{ cm}^{-3}.$$

Since nearly all O is ionized we infer that

$$N(O) = 10^{-1} \text{ cm}^{-3}.$$

Method (2) makes use of the equation

$$\frac{n_2}{n_1} = \frac{N_e a_{21}}{A_{21} + N_e a_{21}} e^{-(h\nu/kT)},$$

where a_{21} is the collisional probability:

$$a_{21} = \sigma^2 2 \left(\frac{2\pi kT}{m}\right)^{1/2} = 3 \times 10^{-10}$$

For the low metastable level

$$e^{-(h\nu/kT)} = 0.4.$$

If we assume $N_e = 1$ cm^{-3}, we get approximately

$$\frac{n_2}{n_1} = \frac{N_2}{N_1} = 5 \times 10^{-6}.$$

Since $n_2 = 10^{12}$ we find

$$n_1 = 2 \times 10^{17}.$$

Adopting again $s_0 = 10^{21}$ cm, we have

$$N_1 = 2 \times 10^{-4}$$

Evidently, the collisional mechanism is much more efficient than the radiation mechanism. The abundance of O may be somewhere between the two limits. Stromgren has independently estimated from the same observational data that the interstellar abundance of oxygen is 10^{-2} or 10^{-3} atoms to one atom of hydrogen. The method upon which these computations are based is very rough, but as a preliminary result we shall adopt

$$N(O) = 10^{-3} \text{ cm}^{-3}$$

The heterogeneity of the Milky Way in regard to the relative intensities of [O II] and II leads to interesting speculations. It may be due to real differences in abundance. But it may also be due to different conditions of excitation.

INTERSTELLAR EMISSION OR ABSORPTION

In the past astronomers have sometimes been searching for interstellar emission lines of Ca II and Na I, and it is of some interest to explain why these lines are observed in absorption, while H is observed in emission. Let us compare the emission of II and Ca II. From the absorption intensities we know that

$$N_2(\text{Ca}^+) = 10^{-8} \text{ cm}^{-3}.$$

The total emissions in H$_\alpha$ and Ca K are

$$4\pi E_\alpha = n_3 h\nu_{32} A_{32} \text{ for H}$$
$$4\pi E_K = n_K h\nu_K A_K \text{ for Ca}^+$$

Since we are only concerned here with orders of magnitude we may put

$$h\nu_{21} = h\nu_K$$

$$A_{21} = A_K$$

Accordingly,

$$\frac{E_a}{E_K} = \frac{n_2}{n_K} = \frac{5}{n_K}$$

because $n_2 = 5$ cm^{-2} (page 248). But

$$n_K = 10^{-8} \times 10^{21} \times W \frac{g_K}{g_1} e^{-(h\nu/kT)}$$

For $T = 15{,}000°$ and $W = 10^{-16}$,

$$\frac{E_a}{E_K} \approx 10^3 \text{ or } 10^4,$$

so that the emission of Ca K can not be observed.

In a similar manner we can show that no interstellar absorption lines of H are expected in the spectra of distant stars, for example in a Nova which provides an emission background on which an interstellar line could easily be seen. The absence of any such line in Nova Lacertae, at a distance of about 900 parsecs, shows that

$$n_2 < 10^{12} \text{ cm}^{-2},$$

because if it were stronger our spectrograms would show it. We also know that for the third level, which is not metastable,

$$n_3 = n_1 W e^{-(h\nu_{13}/kT)} = 5,$$

while for the second, which is metastable.

$$n_2 = n_1 W \frac{A_{31}}{A_{21}} e^{-(h\nu_{13}/kT)},$$

Since $A_{31} = 10^8$ sec^{-1} the inequality becomes

$$\frac{1}{A_{21}} = \tau_2 < 2 \times 10^3 \text{ sec.}$$

The question arises whether this is in accord with the theory. Breit and Teller find that in the absence of collisions the mean life of the $2s$ state of hydrogen is about 1/7 second. Hence the Balmer absorption lines should not be observable.

COMPOSITION OF INTERSTELLAR GAS

Table 5 summarizes the results. I have combined the results of Dunham and Strömgren with my own, without making an attempt to avoid slight inconsistencies. In my opinion the theory, as well as the observations, permits only a very rough orientation. In Dunham's work the atoms refer to the space between the earth and χ^2 Orionis; those for the molecules represent the means for several stars.

TABLE 5 - -COMPOSITION OF INTERSTELLAR GAS
LOGARITHMS OF NUMBERS OF PARTICLES PER CM^3

Element	This paper	Dunham	Sun	Nebulae
Electrons	0 2	1		
Hydrogen	0 2	1	0	0
Oxygen	−3		−1 5	−2
Sodium	−6	−4	−3 3	−1
Potassium		−5	−3 7	−5
Calcium	−7	−5	−3 8	−4
Titanium		−7	−5 3	−4
CH		−6		
CN		−6		

For comparison the table gives also the relative abundances in the sun from Russell and in the nebula NGC 7027 from Bowen and Wyse. These values were adjusted for one hydrogen atom. The discrepancies between the results of this paper and Dunham for Ca and Na are attributable to differences between the determinations of Dunham and of Merrill, Wilson, and Sanford. However, there are real differences in different parts of the sky. Dunham found for the neighborhood of the sun a density of 10^{-10} Ca ions per cm^3; for the space between the earth and χ^2 Orionis he finds 10^{-7}, while Merrill and Sanford find 10^{-6} for the average of many stars. There are also serious difficulties with the curve of growth for interstellar absorption lines. Accordingly, we need feel no concern about the differences. It seems that the composition of the gas is similar to that of the sun and of the nebulae.

It seems to me that the most important task now is to study in detail the heterogeneity of the galaxy. We have definite observational indications that the relative intensities of different atoms are different in various parts of the sky. It is surprising, for example, that some of the newer interstellar lines are strong in ζ Ophiuchi. Adams has shown that λ 4232.6 and CH 4300.3 are relatively strong in this star. But Ca K is not particularly strong. The star is of very early B type (Morgan finds it may even be an O) and probably creates a moderate volume of ionized H. But it lies quite far from the Milky Way and from other O stars. The data now available are not sufficient for a

detailed study, and we can only give a few hints as to the topics such a study might cover.

(1) The relative weakness of K and the strength of molecular lines in ζ Ophiuchi, far from the other O-type stars and from the Milky Way, suggest that the ionized volume is small and that molecular lines are strengthened in the un-ionized regions. We have as yet no accurate theory of the equilibrium of CH and NH and it is difficult to predict the outcome. Swings has made some computations and has shown that certain diatomic molecules, like CH and NH, must be quite frequent. The ionization of H may well impede the formation of the molecules, and it is quite possible that they will be relatively more numerous in the un-ionized regions.

(2) Adams states that Ca I 4227 does not appear in ζ Ophiuchi. This agrees with the prediction of Stromgren's theory (page 249) for a relatively un-ionized region. This is also true of the correlation between Ca I and Ca II, noticed by Adams.

(3) Because of the fact that interstellar Ca II and Na I originate principally in the ionized H regions, we should expect that there would be appreciable departures from the simple one-half relation in the galactic rotation term, which was discovered by Oort, and confirmed by Struve and by Plaskett and Pearce. However, since the regions are large it is important that the comparison of radial velocities be confined to those stars and their Ca II lines which are principally responsible for the creation of a volume of ionized H.

(4) In order to aid in the study of the heterogeneity of the galaxy, more material is required with the nebular spectrographs.

(5) An application of Stromgren's theory to diffuse gaseous nebulae, such as the Orion nebula, and to planetaries, should be made, with special attention to the theoretical and observational study of absorption lines, such as the lines of He I discovered by O. C. Wilson.

(6) A regional study of interstellar Ti II should be relatively easy. From the theory we should expect a behavior which is essentially similar to that of Ca II and Na I.

(7) The observational problem of determining N_i for interstellar H has not been solved with sufficient precision.

(8) A study of the effects of stellar lines in early B stars and the determination of good spectroscopic parallaxes for these stars will improve our knowledge of N_i (Ca^+) and N_1 (Na).

(9) The nature of the contours of the interstellar lines must be cleared up by extending the determination of line contours to very distant stars located near the nodes and near the maxima or minima of the curve of galactic rotation as a function of galactic longitude.

PALEONTOLOGY.—*New Middle Devonian stratigraphic names.*[1]
G. Arthur Cooper, U. S. National Museum, and Aldred S.
Warthin, Vassar College.

These new names are proposed to make them available for use on
the "Devonian Correlation Chart" of the National Research Council.

Stone Mill member of the Ludlowville formation· A thin bed of lime-
stone varying from 1 to 3 feet in thickness and exposed at several lo-
calities on both sides of Chenango Valley in Morrisville Quadrangle,
east-central New York. The type section is located in the bed and
banks of Stone Mill Brook, 4½ miles (airline) southeast of Lebanon
and about 1½ miles northwest of Earlville, N. Y. The layer has only
a local distribution but as the easternmost representative of the Cen-
terfield limestone has considerable stratigraphic significance. It con-
sists mostly of crinoidal and fragmentary shell material but contains
considerable sand. Its westernmost exposure is in a small glen at the
southeastern tip of Bradley Brook Reservoir, and its easternmost
appearance is in a ravine about 2½ miles southwest of Poolville. This
member contains a fairly large fauna the most important species of
which are· *Prismatophyllum* n.sp., "*Spirifer*" *venustus* Hall, *Vitulina
pustulosa* Hall, "*Sp.*" *sculptilis* Hall, and many water-worn corals.

The Stone Mill member represents the last detected appearance of
the Centerfield formation in eastern New York. The overlying fine-
grained sandstone also contains many elements of the Centerfield
fauna but it has not proved possible to trace them beyond the eastern
limit of the Morrisville Quadrangle. It is therefore thought that the
crinoidal and shell debris, together with the rolled corals, represents
an eastern-shore phase of the Centerfield.

Logansport limestone The name of this formation is derived from
the city of Logansport, north-central Indiana, but the exposure se-
lected as the type section is located at Pipe Creek Falls, 2 miles above
the junction of Pipe Creek and the Wabash River, 7 miles above Lo-
gansport. Here 12 feet of light-colored granular limestone overlies the
Silurian at the falls; corals and other fossils are abundant particularly
in the upper 6 feet. Important Centerfield elements in the fauna are:
Camarospira, Eunella attenuata, Camerophoria, Cyclorhina, and "*Spi-
rifer*" *venustus*.

This formation had previously been correlated with the Onondaga
limestone on the basis of the reported presence of *Spirifer acuminatus*
and other Onondaga types. This confusion of Onondaga and Hamilton
types occurred because the Logansport formation has a "reef facies"

like parts of the Onondaga. Re-examination of the fossils shows closest affinities of the Logansport to the Four Mile Dam limestone of the Traverse Group of Michigan.

Hungry Hollow formation: Proposed for the Encrinal limestone and coral bed at the base of the Widder formation in southwestern Ontario. These two beds contain a fauna wholly unlike that of the Widder. Although the Encrinal and coral bed are unlike in lithology the two contain the same fossils and are thus a faunal unit. The type section is in the bluffs along the Aux Sables River in Hungry Hollow (also known as Bartlett's or Marsh's Mill), 2½ miles east of Arkona, Ontario. Here the Hungry Hollow formation consists of 2½ feet of light-brown crinoidal limestone overlain by 3 to 4 feet of calcareous shale abounding in corals and other fossils. The formation contains an almost exact duplication of the Centerfield fauna of western New York.

Four Mile Dam limestone: Type section located at the Four Mile Dam on Thunder Bay River, Alpena County, Mich. The rock exposed at this place is a part of a reef of uncertain thickness overlain unconformably by the Norway Point formation. The Four Mile Dam limestone abounds in fossils of Centerfield affinities: *"Spirifer" venustus, Camarospira, Camerophoria, Cyclorhina, Parazyga,* and *Strombodes alpenensis.*

Newton Creek limestone: Proposed for the brown, bituminous and crystalline limestone 25 feet thick exposed 12 feet above the floor of the Michigan Alkali Company Quarry, Alpena, Mich., and extending to a thin black shale at the base of the Alpena limestone. The formation abounds in large brachiopods· *Cranaena, Pentamerella, Camerophoria,* and *Charionella.*

Rockport Quarry limestone: Proposed to replace Rockport limestone of Smith, 1916 (not Bastin, 1908; Krebs, 1911; or Marbut, 1904). The type section is in the quarry of the Kelly Island Rock and Transport Company at Rockport in the northeast corner of Alpena County, Mich.

BOTANY.—*Elongation of mesocotyls and internodes in Job's-tears (Coix lachryma-jobi L.).*[1] JAMES H. KEMPTON, U. S. Bureau of Plant Industry.

Numerous experiments with maize seedlings grown in the dark have shown that the elongation of the mesocotyl (epicotyl) ceases with the exsertion from the coleoptile of the first leaf. It has been established also that 100 F.C. hours Mazda illumination at approximately 26° C., when the seedlings are 2 to 5 cm tall, result in a reduction in the final length of the mesocotyl of approximately 25 to 30 percent. When the mesocotyl has attained the length maximum for the seed stock and the experimental conditions, further elongation of the seedling takes place in the first internode—the internode between the coleoptile and the first leaf.

Seedlings of the Asiatic maize relative, *Coix lachryma-jobi* L., differ morphologically from those of maize in having a bladeless sheath interposed between the coleoptile and the first true leaf. It was of interest, therefore, to determine for *Coix* whether cessation of elongation of the mesocotyl awaited the appearance of the first true leaf or followed upon the exsertion of the bladeless sheath.

Coix is native to the Oriental humid tropics of very heavy rainfall and may be considered at least semiaquatic in habitat. Importation of seed from the Orient is proscribed because of the prevalence there of a mildew capable of attacking maize. However, the hard-shelled forms have been grown in this country for years as a source of beads, and a stock of this seed was obtained from the W. Atlee Burpee Co.

Preliminary experiments showed that the seedlings of this stock, when grown in the dark, produced mesocotyls almost twice the length of those of the Funk Yellow Dent used in maize experiments. Mesocotyls as long as 450 mm were obtained, and this length at least equals that found in the desert maize of the Hopi Indians.[2] In the case of the Hopi maize, long mesocotyls are an evident adaptation to the deep planting required to place the seed in moist soil, whereas in *Coix* they may be considered as a useful adaptation for an aquatic habitat where the seeds may be buried along stream banks.

The experiments with *Coix* indicated that, with the exsertion of the bladeless sheath from the coleoptile, the elongation of the mesocotyl ceased. However, it developed that upon the cessation of elongation of the mesocotyl further elongation of the seedling took place at

the second internode instead of the first as in maize. The first internode was not extended and the coleoptile and bladeless sheath remained essentially paired as almost opposite organs (Fig. 1).
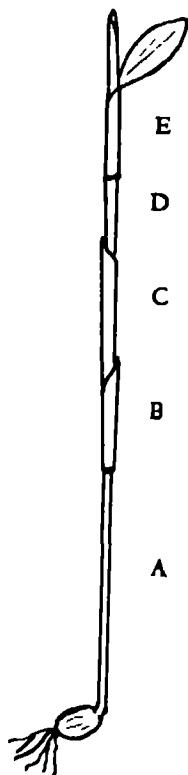
Fig 1 —Diagrammatic representation of *Coix* seedlings (A) Mesocotyl, this organ may elongate 450 mm, (B) coleoptile; (C) bladeless sheath, the node bearing this sheath is not shown but is within 1 or 2 mm of the node at the base of the coleoptile, (D) second internode, (E) first true leaf

A number of experiments have been conducted, all giving the same results. When the mesocotyl is checked, the second internode elongates. A single experiment is presented in Table 1 where one-half of a flat of seedlings growing in the dark was given an exposure of 100 F.C. hours Mazda illumination, the other half remaining in the dark.

From the measurements it is evident that the illumination given one-half the seedlings resulted in a very great reduction in the elongation of mesocotyls and stimulated the elongation of second internodes. No effect of illumination is found in the coleoptiles, though a similar treatment of maize would have measurably increased the length of the coleoptiles. The bladeless sheaths, however, definitely responded

Character	Light exposure		Difference
	Dark throughout	100 F C hours	
	M m	*M m*	*M m*
Mesocotyl	253 71 ± 8 94	133 41 ± 7 90	120 30 ± 11 93
Coleoptile	30 32 + 1 33	30 27 ± 1 11	05 ± 1 74
First sheath	40 87 ± 1 41	56 30 ± 1 75	15 43 ± 2 25
Second internode	—	54 10 ± 3 78	
First true leaf	82 56 + 6 33	144 96 ± 6 71	62 40 ± 9 22

to the brief illumination. Evidently the mesocotyl of *Coix* is much more sensitive to light than is the maize mesocotyl, although this has not been tested beyond the reduction in length effected by 100 F.C. hours. In maize it has been possible to detect the effect of 1,000 F.C. seconds, and it would appear to be possible with *Coix* to measure the response to even smaller amounts of light.

The failure of *Coix* to elongate the internode between the coleoptile and the bladeless sheath is suggestive that this sheath and the coleoptile are more intimately related in function than is the case with maize. The greater sensitivity of *Coix* to light, as compared with maize, and the extensive elongation of *Coix* mesocotyls, together with the close physical association of the coleoptile and bladeless sheath, suggests that both these latter organs produce the growth substance required for mesocotyl elongation.

ZOOLOGY.— *Ostracoda from Puerto Rican bromeliads.*[1] WILLIS L. TRESSLER, University of Maryland. (Communicated by WALDO L. SCHMITT.)

It has been about 60 years since the first discovery of Entomostraca in the leaf cups of bromeliads in southern Brazil. Since then this habitat has been investigated in several places, and a long list of animal forms has been assembled, many of which are found almost exclusively in this peculiar situation.

The bromeliads are large tropical plants built on the lines of a century plant or the pineapple, which is a member of this group. The leaves, which may be several feet in length, are arranged in a spiral fashion with overlapping bases, which form little cups in which rain water collects. Bromeliads are mainly epiphytic on the large trees of tropical America but are found also in most botanical gardens of

temperate regions where they thrive under glass. The cups at the leaf bases are filled with decomposing debris and water, and in the water or among the debris or attached to the sides of the leaves are to be found a great variety of organisms, including copepods, ostracods, and worms.

The first report on Entomostraca inhabiting the leaf cups of bromeliads was made by Fritz Müller in 1880 (Müller, 1880) and concerned the discovery of various microscopic animals that he had found in these reservoirs in southern Brazil. Included was a new species of ostracod, which was described the following year (Müller, 1881). More recently, Picado (1913) in his masterly study of the organisms to be found in the leaf cups of bromeliads, recorded about 250 species of animals that have been found in this habitat in various parts of the world. This list of species includes representatives from such groups as the rotifers, oligochaete worms, leeches, planarians, ostracods, copepods, isopods, Onychophora, Myriapoda, Acarina, Phalangida, Pseudoscorpionida, scorpions, spiders, gastropods, insects, and amphibians. Of these, the insects were by far the most largely represented.

In Brazil, Müller (1881) found an ostracod that he described as *Elpidium bromeliarum* (Figs. 9, 10) but that has since been found to be a species of the already discovered genus *Metacypris*. Only one species of this genus (*M. cordata*, Figs. 7, 8) was known from northern Europe and Hungary, where it was an inhabitant of shallow water along the shores of lakes (G. W. Müller, 1900). It was subsequently found in England as well. A variety of the European species (*M. cordata neocomensis*) was described by Thiebaud (1906) from Switzerland, and an American species (*M. americana*, Fig. 13) by Furtos (1936) from the cenotes of Yucatan. A fourth species is described herein.

Picado found two genera of ostracods in Costa Rica: A species of *Metacypris* (Fig. 11) found at La Mica at 1,500 meters elevation, a form that was considered to be closely related to *M. bromeliarum*, and a species that was referred to the genus *Candona* (Fig. 12) but that was not described. In the present paper the occurrence of another species of ostracod (*Candonopsis kingsleyi*) is recorded from the leaf cups of bromeliads, which brings the total number of ostracod species found in this habitat to three, or perhaps four if Picado's *Metacypris* can be considered a distinct species.

Ostracoda and Entomostraca in general have been found in many strange and unexpected places, the leaf cups of bromeliads being only

TABLE 1.—A COMPARISON OF THE KNOWN SPECIES OF METACYPRIS

Character	cordata	bromeliarum	americana	maricaoensis
Shell-profile	Ovoid Height = ¾ length Highest = posterior ⅓	Ovoid Height = ½ length Highest = in middle	Ovoid Height = ½ length Highest = in middle	Ovoid Height = ½ length Highest = in middle
Ends of valves	Both broadly rounded	Posterior = broadly rounded Anterior = less rounded	Both broadly rounded	Posterior end broadly rounded Anterior end not so much so
Dorsal margin Ventral margin	Nearly straight Sinuated but covered in part by bellied sides	Arched Same as cordata	Gently arched Same	Arched Same
Shell-dorsal view	Very tumid Width = ½ length Anterior end pointed Posterior end rounded	Very tumid Width = ½ length Anterior end less pointed than cordata	Very tumid — Same	Similar to cordata Width = ½ length Similar to cordata
Shell-surface	Small round pits Strong hairs	Smooth, no pits Few hairs	Pits present Few long stiff hairs	No pits, covered with a pattern of polygonal areas in anterior half Broad band of polygonal areas over dorsal shell margin Few hairs
Color	Posterior half = dark grayish brown Greenish mixture in middle Broad light band dorsal border	Not given	Gray	Gray, polygonal areas brown
Length	0.56 mm	1.2–1.3 mm	0.55 mm	0.78 mm
First antenna	Slender Six segments Spine on second segment poorly developed	Five segments Dorsal border of first segment terminates in a thickly haired wart Spine reaches to middle of fourth segment	Five segments Spine reaches to middle of terminal claw	Five segments Spine reaches to middle of fourth segment
Second antenna	Exopodite well developed, reaches to tips of claws	Same as cordata	Exopodite long, slender, reaches beyond tips of terminal claws	Exopodite well developed, reaches to tips of terminal claws
Mandibular teeth	Four to five teeth, each with 2 or more points	Seven teeth	Seven teeth, each split	Eight teeth, not split
Thoracic legs	Broad at base	Similar	Similar	Similar to others
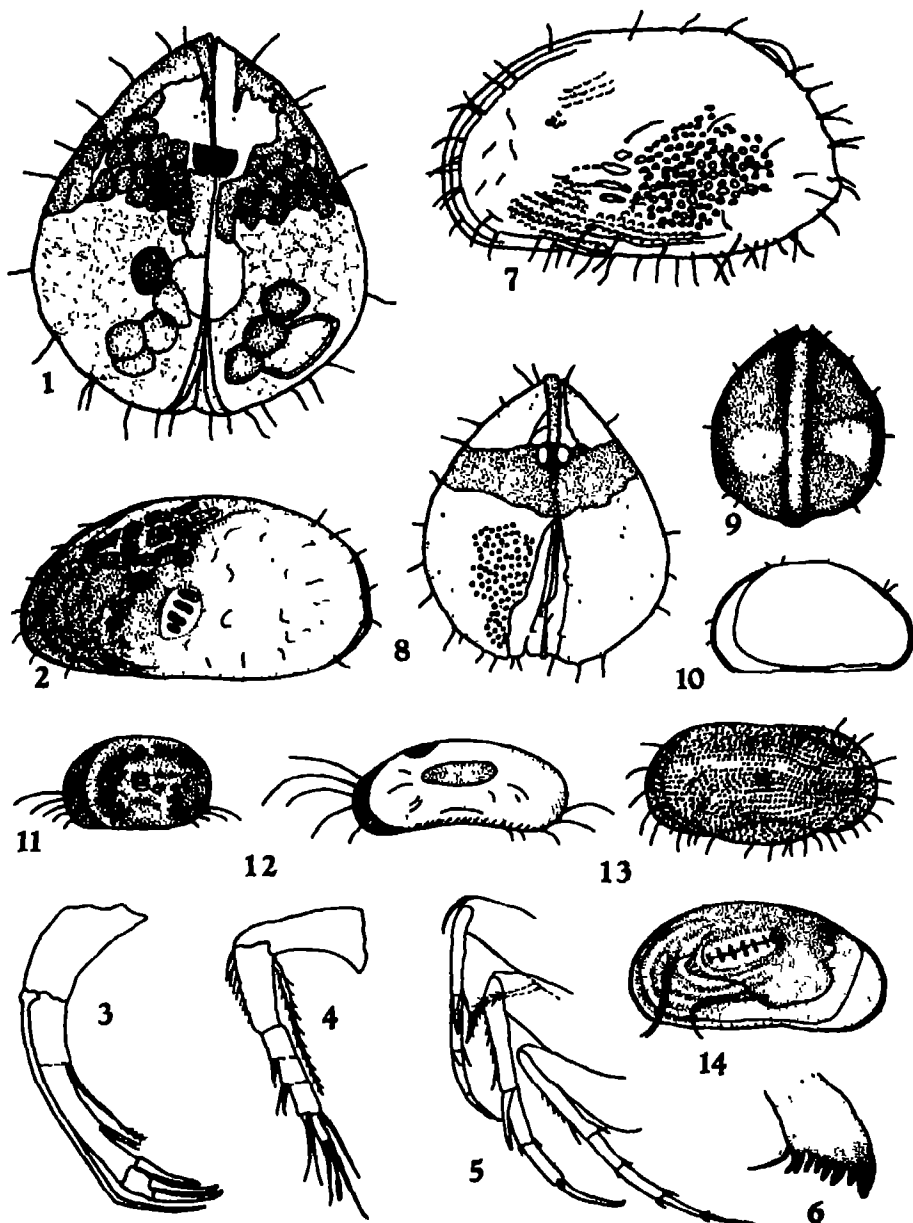
Figs 1–6 —*Metacypris maricaoensis*, n sp 1, Dorsal view, female; 2, left valve, female; 3, second antenna, female; 4, first antenna, female; 5, thoracic legs, female; 6, mandibular teeth, female Figs 7–8 —*Metacypris cordata* G W Müller: 7, Left valve, female; 8, dorsal view, female Figs 9–10 —*Metacypris bromeliarum* (Fr. Müller). 9, Dorsal view, female; 10, left valve, viewed from within, female Fig 11 — *Metacypris* sp (from Costa Rica) Fig 12 —*Candona* sp (from Costa Rica). Fig. 13 —*Metacypris americana* Furtos, right valve, female Fig 14 —*Candonopsis kingsleyi* Brady and Robertson, lateral view, male (Figs 7–8, after G. W Müller; 9–10, after Fr. Müller; 11–12, after Picado; 13, after Furtos.)

one of the many peculiar habitats that these creatures select for their life abode. Some species have been found only in these strange places, a fact clearly brought out in an interesting recent paper by Scourfield (1938).

The material reported upon in the present paper was sent to the author for identification by Dr. Waldo L. Schmitt, curator of marine invertebrates, U. S. National Museum. The collections had been made in the Maricao National Forest in Puerto Rico in 1936 and 1937 by Prof. George S. Tullock, of Brooklyn College, and Prof. W. A. Hoffman, of the Columbia School of Tropical Medicine, San Juan.

The slides of the dissected ostracods and the specimens in alcohol have been desposited in the U. S. National Museum as type specimens.

<div align="center">Suborder PODOCOPA</div>

<div align="center">Family CYPRIDAE. Subfamily CYPRINAE</div>

<div align="center">Genus Candonopsis Vavra, 1891</div>

Laterally compressed forms with thin shells Anterior antennae, slender, posterior antennae, with penultimate joint subdivided, natatory setae poorly developed. Mandibular palp long and slender with a much-produced terminal joint Maxillipeds with a vibratory plate bearing three thick plumose setae; palp in male transformed as in *Candona* into a prehensile organ. Dorsal margin of furca without setae

This genus includes one species found in Europe and several from the Southern Hemisphere.

<div align="center">Candonopsis kingsleyi (Brady and Robertson)   Fig 14</div>

Candona kingsleyi (part) Brady and Robertson, Ann Mag Nat Hist
   (ser. 4) 6: 17, pl figs 11, 12. 1870
Candonopsis kingsleyi Vavra, Sitzber Böhm Ges , 1891, p 162
Candonopsis kingsleyi Müller, Zool 30: 38, pl 6, figs 6, 7, 23–28; pl 7, figs
   22, 25. 1900.

Specific characters.—Female Seen from the side, reniform with rounded ends, highest a little posterior to the middle Posterior end slightly more broadly rounded than the anterior end Dorsal margin forming an evenly rounded curve; ventral margin slightly concave From above, very narrow with greatest width slightly behind the middle; anterior end somewhat more pointed than the posterior. Valves with very smooth shiny surfaces and with a few fine hairs. Inner duplicatures very broad, particularly at the anterior end where the inner edge forms an almost vertical line. Anterior antennae long and slender, posterior antennae also slender. Mandibular palp with terminal joint narrowly produced and of about the same length as the preceding joint. Maxillipeds with tapering palp exhibiting a very small terminal joint. Second pair of legs with the two shorter bristles of unequal length, the shorter being less than one half the length of the other. Furcal rami very narrow and slightly curved, without dorsal seta; claws without strong teeth.

Male, somewhat larger than the female. Prehensile palps of maxillipeds

short and thick and slightly unequal, the right being broader. Copulatory appendages terminate in two unequal lappets, the upper one being larger and of triangular shape. Ejaculatory tubes are very large and conspicuous and are distinctly visible through the transparent shell. Color whitish, translucent. Length of male, 1.06 mm; height, 0.54 mm; width, ca. 0.20 mm. Female slightly smaller.

Occurrence.—From bromeliads, Maricao National Forest, Puerto Rico, 2,800–3,000 feet elevation, December 1937.

Distribution.—Sweden, British Isles, Germany, Bohemia, Switzerland, Siberia.

Family CYTHERIDAE

Genus **Metacypris** Brady and Robertson, 1870

Metacypris Brady and Robertson, Ann. Mag. Nat. Hist. (ser. 4) 6: 19. 1870.
Elpidium F. Müller, Arch. Mus. Nac. Rio de Janeiro 4: 27. 1881.
Metacypris G. W. Muller, Zool. 30: 95, pl. 21, figs. 1–9. 1900.
Metacypris Thiebaud, Zool. Anz. 29: 799. 1906.
Metacypris Furtos, Carnegie Inst. Washington Publ. 457: 114, figs. 31, 32, 44–46. 1936.

Very short broad shells; right valve with toothed anterior and posterior margins. First antennae with five or six segments. Second antennae, four segmented, the exopodite jointed. Mandibles with obscurely segmented palp. Maxilla with three masticatory processes and a shorter palp; branchial plate without aberrant or orally directed setae. Furca of female with three setae.

Metacypris maricaoensis, n. sp   Figs. 1–6

Specific characters.—*Female:* From the side, oval in outline with greatest height at about the center. Dorsal margin broadly arched, ventral margin almost straight. Both ends rounded, the posterior end being more broadly rounded than the anterior, which shows a pronounced slope from the dorsal margin. Seen from above, very tumid with broadly rounded posterior and more tapered anterior ends. Large fused eyes very prominent. Valves smooth with a few scattered, strong hairs. Color, gray with a much darker area in the anterior half of the valve which consists of a band of polygonal shaped, dark brown areas across the two valves at the region of the eyes. First antenna with five segments, the spine on the second segment well developed and reaching to the middle of the fourth segment. Second antenna with well developed exopodite which reaches to the tips of the terminal claws. Mandible with eight teeth which show no evidence of being split. Thoracic legs broad at the base and in other respects similar to those of other members of the genus.

Length of adult female, 0.78 mm, height, 0.39 mm, width, 0.64 mm.
Male unknown.

Occurrence.—Numerous specimens were taken from leaf cups of bromeliads in the Maricao National Forest, Puerto Rico, at an elevation of 2,800–3,000 feet, January 28, 1936, and December 1937. Female holotype, U.S.N.M. no. 80029.

Remarks.—This species is evidently closely related to *M. cordata* but differs from it in several important respects, viz. the greater size, shape of the shell and the color markings, the absence of pits on the valves, and the marked difference in the mandibular teeth.

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SCOURFIELD, D. J.   *Entomostraca in strange places*   Journ Quekett Micr Club (ser 4) 1(3): 116–122. 1939

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ICHTHYOLOGY.—*Kraemeria bryani, a new species of trichonotid fish from the Hawaiian Islands.*[1] LEONARD P. SCHULTZ, U. S. National Museum.

The reference of genera of fishes to the family Trichonotidae by various authors from time to time has frequently been the result of inadequate material for comparison of their anatomical characters. The genera centering around *Kraemeria* have features that resemble the trichonotids more than the gobiids, and this has influenced me to place them in a subfamily. However, *Paragobioides* Kendall and Goldsborough has been referred to this group by Fowler, but it certainly does not resemble any of the trichonotids except by its elongated body and numerous fin rays. Some pores over the eye, no lateral line, and the restricted gill opening cause me to conclude that *Paragobioides* is nearer the Gobiidae than the Trichonotidae. Its true relationship will be determined no doubt from a study of its skeleton, and until that is done I propose to consider it tentatively as a distinct subfamily. Thus I am inclined to believe that Hora (Rec. Indian Mus. 27 (pt. 6): 455. 1925) in referring *Paragobioides* to the subfamily Taenioidinae under the Gobiidae is close to the true relationship of this species.

In order to separate the various genera referred to the family at various times (from a practical viewpoint) and to indicate some of the relationships between Hawaiian, Samoan, and Phoenix Island material, I have prepared a key and incorporated the various genera as noticed by me in the literature.

1*a*. Lateral line present, below the midaxis at least posteriorly, lower jaw shortest, snout projecting in front of the thin and weak lower jaw; tip of tongue free, narrow and pointed, not bilobed, gill membranes extending far forward, free from isthmus (LIMNICHTHYINAE).

2a. Lateral line along midaxis anteriorly, below it posteriorly, meeting or nearly meeting its fellow behind the anal fin; snout much projecting in front of lower jaw, tip of snout fleshy, protractile; lips of lower jaw with cirri on sides.

  3a. Sides of body fully scaled; pelvic rays I, 5; dorsal fin rays fewer than 30; fewer than 45 scales in lateral line.

    4a. Dorsal fin rays about 25 or 26; anal 27 to 29; pectoral 13, the lower rays not separated and different from upper rays; scales in lateral line about 40   *Limnichthys*[2] Waite

    4b. Dorsal rays 19; anal 29; pectoral 8+9 = 17, lower rays longer than and somewhat separated from upper rays; scales in lateral line 37   *Schizochirus*[3] Waite

2b Lateral line below midaxis anteriorly, abruptly decurved behind pectoral fin, then continuing about halfway from midaxis to base of anal fin along lower side but not meeting its fellow behind anal fin; snout a little longer than lower jaw and somewhat fleshy; dorsal origin behind that of anal, over third to fourth anal ray, dorsal rays 35, anal 42; pectoral 15; pelvics I, 5 . *Tewara*[4] Griffin

  3b. Sides of body not fully scaled, naked at least above and below lateral line anteriorly; dorsal fin rays more than 30; about 53 to 60 pores and scales in lateral line; dorsal rays 37 or 38; anal 35 to 37; pores in lateral line 54; pelvic rays I, 5; the only scales present occur along lateral line   . *Crystallodytes cookei*[5] Fowler

1b. Lateral line present or absent; if present its course is along midaxis and not below it; snout either shorter than lower jaw (the latter strongly projecting) or lower and upper jaws about same length

  5a. Body naked; gill membranes narrowly attached to isthmus free for some distance forward; tongue bilobed; dorsal rays about 19 or 20, about first 5 simple; anal about 13 to 15, the first ray probably simple; pelvics I, 5; inner rays longest; about 9 or 10 branched rays in caudal fin (KRAEMERINAE).

    6a. Pectoral rays 3 to 5; dorsal rays 19 or 20; anal 12 to 14, rarely 15.   *Kraemeria bryani*, n. sp.

    6b. Pectoral rays 7 or 8, dorsal rays 19 or 20, anal usually 14 or 15.   *Kraemeria samoensis* Steindachner

  5b. Body fully scaled, although scales may be minute on *Paragobioides*, in which case dorsal rays about 60, tongue not bilobed but rounded or pointed.

    7a Gill membranes not widely joined to isthmus but free forward, gill opening not restricted to sides (TRICHONOTINAE).

      8a. First one or two anterior rays of dorsal long and filamentous; inner rays of pelvics long and filamentous   *Trichonotus*[6] Bloch in Schneider; *Taeniolabrus*[6] Steindachner

[2] *Limnichthys* Waite, Rec Australian Mus 5(pt 3): 178 1904 (genotype, *Limnichthys fasciatus* Waite, ibid., pp 178–179, pl 23, fig 4, monotypic); McCulloch, Australian Zool 2(pt 3): 102, fig 276a. 1922

[3] *Schizochirus* Waite, Rec. Australian Mus 5(pt 4): 240 1904 (genotype, *Schizochirus insolens* Waite, ibid., pp 242–243, figs. 33, 34, pl 26, fig 3, monotypic); McCulloch, Australian Zool. 2(pt 3). 102, fig 277a 1922.

[4] *Tewara* Griffin, Trans. Proc. New Zealand Inst 63(pt. 2): 174–176, pl 25, upper fig 1933 (genotype, *Tewara cranwelli* Griffin).

[5] *Crystallodytes cookei* Fowler, Occ Pap B P Bishop Mus. 8: 390–392 1923 (type locality: Laie Beach, Oahu), Fowler, Fishes of Oceania, Mem B P. Bishop Mus 10: 426, fig 60 1928; Pietschmann, B P Bishop Mus Bull. 156: 44, pl. 16, B 1938.

[6] *Trichonotus* Bloch in Schneider, Syst Ichthy , p 179 1801 (genotype, *Trichonotus setiger* Bloch in Schneider).

8b. First rays of dorsal and last rays of pelvics not elongate or filamentous. *Hemerocoetes*[7] Cuvier and Valenciennes; *Creedia*[7] Ogilby; *Lesueurina*[7] Fowler; *Squamicreedia*[7] Rendahl

7b. Gill membranes broadly joined to isthmus, gill opening mostly restricted to sides; dorsal rays 60; anal 37; pectoral 14 or 15; pelvics? I, 4; scales minute, not visible on young; no lateral line; anus under twenty-fifth dorsal ray; 11 branched rays in caudal fin (15 jointed rays) (PARAGOBIOIDINAE)

Paragobioides[8] Kendall and Goldsborough

Kraemeria Steindachner

Kraemeria Steindachner, Akad. Wiss. Wien 115 (Abt. 1): 41 July 1906 (type, *Kraemeria samoensis* Steindachner).

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Kraemeria bryani, n. sp.

Kraemeria samoensis Fowler (not of Steindachner), Fishes of Oceania, B P. Bishop Mus. Mem. 10: 425, fig 68 1928, Pietschmann, B. P. Bishop Mus. Bull. 156: 43, pl 16, A. 1938

Holotype —A specimen, 15 1 mm in standard length, collected by C. M. Cooke, Jr , March 1928, at Malaekahana, Oahu, Hawaiian Islands, U S.N.M no. 109380. The following paratypes, 18 to 20 mm, were studied: 10 from Malaekahana, Oahu, May 30 -31, 1926, collected by C. M. Cooke, Jr ; 7 bearing the number 4905 in the Bishop Museum and 2 now catalogued as U.S N M. no. 116181; 6 from Laie, Oahu, taken June 4, 1923, by C M. Cooke, Jr , 4 having number 4904 in the Bishop Museum and 2 U.S.N.M. no. 116180, 3 from Laie Beach, Oahu, collected by C M. Cooke, Jr., November 2, 1922, no 4902 in Bishop Museum.

Description based on the holotype and paratypes All measurements are expressed in hundredths of the standard length, those for the holotype out-

Taeniolabrus Steindachner, Sitzb Akad Wiss Wien **55**: 713 1867 (type, *T filamentosus* Steindachner)

Taeniolabrus marleyi Smith, Trans Royal Soc South Africa 24(pt 1) 4–6, pls 1, 2 1936 (type locality: Durban)

[7] *Hemerocoetes* Cuvier and Valenciennes, Hist Nat Poiss. **12**: 311 1837 (type, *Callionymus acanthorhynchus* Forster)

Creedia Ogilby, Proc Linn Soc New South Wales 23(3). 298 1898 (type, *Creedia clathrisquamis* Ogilby, McCulloch, Australian Zool 2(pt 3): 101, pl 31, fig 275a, of *Creedia clathrisquamis* Ogilby 1922)

Hemerocoetes haswelli Ramsey, Proc Linn Soc New South Wales **6**: 575 1881. (type locality: North Head of Port Jackson)

Lesueurina Fowler, Proc Acad Nat Sci Philadelphia, 1907, p 440 [type, *Lesueurina platycephala* Fowler (*Lesueurella platycephalus* Fowler, misprint)].

Squamicreedia Rendahl, Svenska Vet Hand **61**(9): 20. 1921 (type, *Squamicreedia obtusa* Rendahl)

[8] *Paragobioides* Kendall and Goldsborough, Mem Mus Comp. Zool **26**(7): 324, pl. 6, fig 2. 1911 (type, *Paragobioides grandoculis* Kendall and Goldsborough); Fowler, Acad. Nat. Sci. Philadelphia Monog. **2**: 206–207. 1938.

side the parentheses and for the paratypes within parentheses. Standard length 15.1 (19.5; 19.7; 20.3 mm); length of head 29.8 (25.4; 25.4; 27.0); greatest depth 10.0 (11.6; 9.7; 11.8); diameter of eye 1.3 (2.0; 1.5; 2.0); length of snout 3.3 (3.5; 5.1; 4.4); length from tip of lower jaw to rear edge of maxillary 5.8 (–; –; 6.9); length from tip of lower jaw to rear edge of maxillary 8.6 (8.1; 8.6; 9.4); length from tip of snout to anus 53 (–; 56.4; 57.2); length from snout to origin of dorsal fin 31.7 (–; –; 30.3); length of longest pelvic fin ray (10.6 (10.1; 11.6; 11.8); length of longest pectoral fin ray 4 0 (4.6, 4.0; 3.9); length of longest caudal fin ray 15 9 (14.7; 16.3; 15.7); postorbital length of head 22.5 (19.8; 18.8; 19.7).

The following counts were made: Dorsal fin rays 19(4); 20(12); the numbers in parentheses indicate the number of counts; anal rays 12(2); 13(3); 14(12); 15(1); pectoral rays 3(9); 4(24); 5(2); pelvics always I, 5.

The dorsal fin almost equal distance between rear border of orbit and origin of anal fin or over the tips of the pelvic fins; the anal fin origin is under the 8 or 9 dorsal fin ray; the operculum covers the base of the pectoral fin and is attached to it dorsally; the opercular apparatus is not emarginate to fit around the bases of the pelvic fins; gill membranes are narrowly attached to the isthmus, and the gill opening does not extend as far forward as in *Crystallodytes* or *Chalixodytes;* the body and head are scaleless, and there is no trace of a lateral line; the rays in the dorsal, pelvic, and pectoral fins are unbranched; the first 6 dorsal rays and the first anal ray lack the cross marks or joints; the next to the inside ray of the pelvic fin is longest and the fifth

Fig 1 —*Kraemeria bryani,* n sp (not *K samoensis* Steindachner), after Pietschmann, 1938, pl 16, fig. A

ray is of about equal length; the lower margin of the lower lip, the lower margins of the suborbital and the lower margin of the preopercle are papillate; the lower jaw is longer than upper and the mouth is oblique, the tip of the lower jaw is fleshy and is pyramidal in shape with the apex pointing forward and ventrally, the eyes are close together in the top of the head; the premaxillary is not protractile, the tip of the snout has a frenum; tongue bilobed at tip.

The color has faded in alcohol and no pigmented areas are visible. The eyes are blackish.

This species differs from others in the genus *Kraemeria* in having but 3 to 5 pectoral fin rays instead of 7 or 8 as found in *Kraemeria samoensis* Steindachner and *Kraemeria samoensis merensis* Whitley (Rec. Australian Mus. 19: 244–246, fig. 11. 1935).

Named *bryani* in honor of my good friend E. H. Bryan, curator of collections, Bernice P. Bishop Museum, Honolulu.

GEOPHYSICS.—*Heat energy from radioactive sources in the earth.*[1] William D. Urry, Geophysical Laboratory, Carnegie Institution of Washington. (Communicated by L. H. Adams.)

The production of heat accompanying the disintegration of the radio-elements, despite the extreme dissemination of these elements throughout the material of the earth, is far from negligible in any treatment of the geothermal history. Some investigators have found it even necessary to postulate a concentration of the radio-elements into the outer shells,[2] a postulate that is borne out, at least qualitatively, by existing hypotheses of the structure of the interior and the few radioactive measurements that have been made, particularly for the ultrabasic rocks.

All the treatments of the geothermal processes[3] indicate the necessity for a more detailed survey of the heat contribution from the radioactive sources. In determining the rate of production of heat in a specimen, it is necessary to consider the elements of the uranium series, the actino-uranium series, and the thorium series. There are in addition certain isotopes of the elements usually considered as stable that are radioactive, but the isotope 40 of potassium alone occurs in sufficient quantity to require inclusion.

METHODS

The major portion of the heat data at present available has been accumulated by laborious determinations of the radon content[4] from which the contribution of the uranium and the isotopic actino-uranium series can be calculated, still more difficult and less frequent determinations of the thoron content[5] to calculate the allotment from

[1] Received May 22, 1941.

[2] Jeffreys, H *The earth* 1929, Holmes, A Journ Washington Acad Sci 23: 169 1933

[3] Jeffreys, H *Op cit*, Holmes, A *Op cit*. Lowan, A N Phys Rev. 44. 769. 1933; Van Orstrand, C E. Geophysics 5: 57 1940; and others

[4] Piggot, C. S. Amer Journ Sci 17: 13 1929; Evans, R D Rev Sci Instr 6: 99 1935; Urry, Wm D Journ Chem Phys 4: 40 1936

[5] Urry, Wm D Journ. Chem Phys 4: 34 1936

the thorium series, and in but a few cases a chemical analysis for potassium.

An important item in the program of the Geophysical Laboratory has been the determination of the heat production by radioactive elements in rocks. Having in mind the need for a large number of separate measurements, the Director of the Laboratory at one time or another discussed with various individuals the feasibility of more rapid and convenient methods for determining the radioactive heat production in representative rocks from all parts of the world; and in particular he requested the present author to examine the possibility of determining heat production in materials containing small amounts of radium and thorium together with their disintegration products, merely by measurement of the rate of alpha-particle emission. It turns out that it is possible by a single measurement to determine with sufficient accuracy the heat production in a rock sample, provided that the potassium content of the rock is already known. The measurement involves only a simple mechanical preparation of the specimen and utilizes the newly developed methods[6] for counting the alpha-particles emitted by solids. A simultaneous count of the beta-rays would determine the contribution of the potassium but, as will be shown, this extra measurement would hardly now be worth while.

While the separate determinations of uranium and thorium are never likely to produce a sufficient body of data for a study of the geothermal history, they do provide knowledge of the probable limits of an independent variable that enters into the equation for calculating the heat quantity by the method of counting all the alpha-particles. This variable, the thorium to uranium ratio, is not determinable by the counting method alone. The following derivation demonstrates that by adopting a certain fixed value for the Th/U ratio, an error of less than 5 percent is introduced in the calculation of the heat production by the counting method for values of the Th/U ratio from 0 to 20. This range covers all values of the Th/U ratio that have previously been found for iron and stony meteorites, ultrabasic, basic, and acidic igneous rocks, sedimentary rocks, and nearly all minerals with the exception of those classified as radioactive.

CALCULATION OF HEAT PRODUCTION FROM ALPHA-PARTICLE COUNT

The following symbols will be used:

N = Total number of alpha-particles emitted per gram per hour from the specimen.

N_U = Number of atoms of all isotopes of uranium per gram at present.

[6] FINNEY, G D, and EVANS, R D   Phys Rev. 46: 503   1935; URRY, WM. D Rev Sci Instr 12: 289. 1941.

N_{UI} = Number of atoms of uranium I per gram at present.
N_{AcU} = Number of atoms of actino-uranium per gram at present.
N_{Th} = Number of atoms of thorium per gram at present
N_K = Number of atoms of potassium-40 isotope per gram at present
P = Thorium to uranium ratio by weight at present
Q = Potassium to uranium ratio by weight at present.
f = Number of potassium-40 atoms as a fraction of all potassium atoms
a = Grams of K_2O per gram of specimen
R = Present-day activity ratio of the actino-uranium series to the uranium series
k = Present-day ratio of N_{AcU} to N_{UI}
h_{UI} = Total energy loss accompanying the conversion of one UI atom to the stable end-product of the series
h_{AcU} = Total energy loss for one AcU atom
h_{Th} = Total energy loss for one Th atom
h_K = Total energy loss for one K atom
h = Production of heat in calories per gram per hour
H = Production of heat in calories per gram per year
$\overline{H}$ = H with the rate of production from potassium added
λ = Disintegration constant of UI, AcU, Th, and K-40 indicated by the appropriate subscript
ϕ = Ratio of $\overline{H}$ for various values of a to the value of $\overline{H}$ for a fixed value of a

The radio-elements in the specimen are assumed to be in equilibrium; therefore the number of alpha-particles emitted[7] per gram per hour is given by

$$N = 8\lambda_{UI}N_{UI} + 7\lambda_{AcU}N_{AcU} + 6\lambda_{Th}N_{Th} \tag{1}$$

8, 7, and 6 being the respective number of alpha-particles emitted in the UI, AcU, and Th series and the disintegration constants being in reciprocal hours. From the definition of the activity ratio R,

$$(\lambda_{AcU}N_{AcU}) = R(\lambda_{UI}N_{UI}). \tag{2}$$

Introducing the atomic weights of uranium (238.045) and thorium (232.12), we have

$$N_{Th} = 1\ 026PN_U \tag{3}$$

Now

$$N_U = N_{UI} + N_{AcU}, \tag{4}$$

because the number of atoms of uranium II can be neglected. By the definition of k and from equation (4),

$$N_U = (1 + k)N_{UI}, \tag{5}$$

and hence

$$N_{\text{Th}} = 1.026P(1 + k)N_{\text{UI}}. \tag{6}$$

Equation (1) can be rearranged with the aid of equations (2) and (6) to give

$$\lambda_{\text{UI}}N_{\text{UI}} = N/[8 + 7R + 6 \times 1\,026P(1 + k)(\lambda_{\text{Th}}/\lambda_{\text{UI}})]. \tag{7}$$

The production of heat, h, from the three radioactive series is given by

$$h = \lambda_{\text{UI}}N_{\text{UI}}h_{\text{UI}} + \lambda_{\text{AcU}}N_{\text{AcU}}h_{\text{AcU}} + \lambda_{\text{Th}}N_{\text{Th}}h_{\text{Th}}, \tag{8}$$

which with the aid of equations (2), (6), and (7) can be written

$$h = N\left[\frac{h_{\text{UI}} + Rh_{\text{AcU}} + 1.026P(1 + k)(\lambda_{\text{Th}}/\lambda_{\text{UI}})h_{\text{Th}}}{8 + 7R + 6 \times 1.026P(1 + k)(\lambda_{\text{Th}}/\lambda_{\text{UI}})}\right] \tag{9}$$

Equation (9) gives the required quantity h in terms of only two variables N and P. Table 1 gives the values of the constants in equation (9).

TABLE 1.—VALUES OF THE RADIOACTIVE CONSTANTS

$R = 0\,040^a$	$k = 1/139^h$	$f = 1/9217^c$
$\lambda_{\text{UI}} = 1\,52 \times 10^{-10}$ yr^{-1b}		$\lambda_{\text{AcU}} = 9\,72 \times 10^{-10}$ yr^{-1b}
$\lambda_{\text{Th}} = 4\,99 \times 10^{-11}$ yr^{-1d}		$\lambda_{\text{K}} = 4\,3 \times 10^{-10}$ yr^{-1c}

Constant	Mass equivalent^f	Ergs^g	Calories^i
h_{UI}	0 0512	7 59 × 10^{-4}	1 82 × 10^{-11}
h_{AcU}	0 0508	7 53	1 80
h_{Th}	0 0432	6 40	1 53
h_{K}	—	0 03^h	0 007

[a] NIER, A O Phys Rev 55 153 1939
[b] NIER, A O Phys Rev 55 150 1939
[c] NIER, A O Phys Rev 50 1041 1936
[d] KOVARIK, A F, and ADAMS, N I Phys Rev 53 928 1938
[e] Calculated from a specific activity of 23 betas g K^{-1} sec^{-1} (MUHLHOFF, W Ann der Physik 399. 205 1930) with atomic weight of potassium 39 10 and f given above
[f] The mass equivalent of the total alpha, beta, and gamma ray energy loss in the respective series summed from a table in WESTERN, F, and RUARK, A E Journ Chem Phys 1 717 1933
[g] Unit mass equivalent = 1 482 × 10^6 ergs
[h] Calculated from E_{max} =0 7 × 10^6 e v (ANDERSON, C D, and NEDDERMEYER, S H Phys Rev 45 653 1934) and 3γs of 2 × 10^6 e v per 100 beta rays (GRAY, L H, and TARRANT, G T P Proc Roy Soc 143A 681 1934)
[i] 1 calorie (20° C) = 4 18 × 10^7 ergs

Substituting the values of Table 1 in equation (9), we have

$$h = N \times 10^{-12}[(1.90 + 0\,52P)/(8\,32 + 2.04P)]. \tag{10}$$

Table 2 shows that the quantity h is relatively insensitive to considerable changes in P and that the term involving P in equation (10) may be assigned a value of 0.240 with a consequent error in the value of h of less than 5 percent for a range of P from 0 to 20. This range more than covers the normal spread of Th/U ratios reported in the literature for all types of igneous rocks and most minerals.[8] The

[8] For a summary of the earlier values of this ratio see Nat Res Council Bull No 80, *Physics of the earth. IV The age of the earth*, p. 218 1931; KEEVIL, N B. Econ Geol.

TABLE 2.—VALUES OF THE P-TERM IN EQUATION (10) AND ITS DEVIATION FROM A FIXED VALUE

P	$h/(N \times 10^{-12})$	Percent deviation from the value for $P = 3$
0	0 228	−4 6
1	0 234	−2 1
2	0 237	−0 8
3	0 239	0 0
4	0 242	+1 3
6	0 244	+2 1
10	0 247	+3 4
20	0 250	+4 6

radium (uranium) and thorium analyses of rocks show a distribution that is markedly peaked between $P = 2$ and 5.

Equation (10) may therefore be written in terms of one quantity N, which can be measured by a single experiment. In equation (11), h is expressed in a more convenient unit:

$$H(\text{cals gram}^{-1} \text{ year}^{-1}) = 2 1 \times 10^{-9} N \tag{11}$$

The design of an ionization chamber used in this Laboratory to determine values of N from solid sources is described elsewhere.[9] Pulses due to the energy released in the emission of the individual alpha-particles can be amplified and recorded with any one of a variety of electrometer tube or linear pulse amplifier circuits.

Potassium.— The production of heat accompanying the disintegration of potassium must be added to the quantity H in equation (11) to give the total production H. This is a quantity $\lambda_K N_K h_K$ analogous to the terms in equation (8) and is equal to $4.3 \times 10^{-6} \times a$ calories per gram per year with the values from Table 1, where a is the grams of K_2O per gram.

It is hardly to be hoped that chemical analyses for potassium will be available in all the specimens to be measured for $\overline{H}$, and the determination of potassium by beta-ray counting requires an extra measurement that it is desirable to avoid. In an attempt to find fixed values for $\lambda_K N_K h_K$ that can be assigned to particular groups of rocks, a statistical examination of 4,724 analyses of rocks compiled by H. S. Washington was made.[10] The largest group, consisting of 1,370 analy-

33: 685   1038; JEFFREYS, H   Gerland Beitr Geophysik 47: 149   1936   Since this paper was first written a valuable contribution to the radioactivity measurements of rocks has appeared—EVANS, R D , and GOODMAN, C   Bull. Geol Soc Amer 52: 459   1941   Their measurements indicate appreciable shifts in the Th/U ratios compared to earlier values, but the new values are still well within the range of P treated here

[9] URRY, WM D   Rev Sci Instr 12: 289   1941
[10] WASHINGTON, H S   U S Geol Surv Prof Paper 99   1917   The examination was confined to Pt I, *Superior analyses of fresh rocks*

ses, was one of the granites, quartz-porphyries, granite-porphyries, and quartz-monzonites. Of this group 31 percent have values of a between 0.04 and 0.05, and 70 percent between 0.03 and 0.06, while 98 percent lie between 0 and 0.07. Rhyolites and aplites show a similar distribution. The classification was based on a division of the rocks into 19 groups, several of which showed very similar distributions.

In order to test the possible error introduced by assigning a group mode to the value of a, a total heat ratio, ϕ, was calculated for various values of the K_2O content a', from 0.0 up to that value that includes at least 98 percent of all the members of the group (the 0.98 limit). ϕ is defined by the following equation:

$$\phi = \frac{2.1 \times 10^{-9} N + 4 3 \times 10^{-6} a'}{2.1 \times 10^{-9} N + 4 3 \times 10^{-6} a} \tag{12}$$

The probable limits of N for any group can be determined from the values of the radium content, Ra, in the literature and the following equation derived from equations (5) and (7):

$$N = \frac{N_U \lambda_{UI}(8 32 + 2.04P)}{(1 + k)} \tag{13}$$

The uranium content by weight is given by $Ra/3.49 \times 10^{-7}$ and

$$N = 1.25 \times 10^{14} Ra(8 32 + 2 04P) \tag{14}$$

Figs. 1 and 2 show, by the departure of ϕ from unity, the uncertainty in the total production of radioactive heat in a rock due to assigning a fixed value of a in place of an experimental value. The uncertainty decreases with increasing values of P and N. P may be as low as 1 without sufficient increase in the uncertainty to show in Fig. 1.

Values of the radium content are few and unsatisfactory in the ultrabasic group of pyroxenites, peridotites, magnetites, and hornblendites. A dunite from North Carolina has yielded values as low as 0.005×10^{-12} g Ra per g. This value gives $N = 11$ for $P = 4$, which for a sample of 100 mg would result in a count of less than 0.5 alpha-particles per hour. This is outside the observational limit of present counting devices. A practical lower limit of $N = 50$ may be taken. Fig. 2 shows that the uncertainty ratio ϕ may depart appreciably from 1.0 for this group, although the maximum error is not much in excess of the accuracy with which $N = 50$ can be determined. The radium and thorium contents of a number of specimens of this group are being determined in this Laboratory.
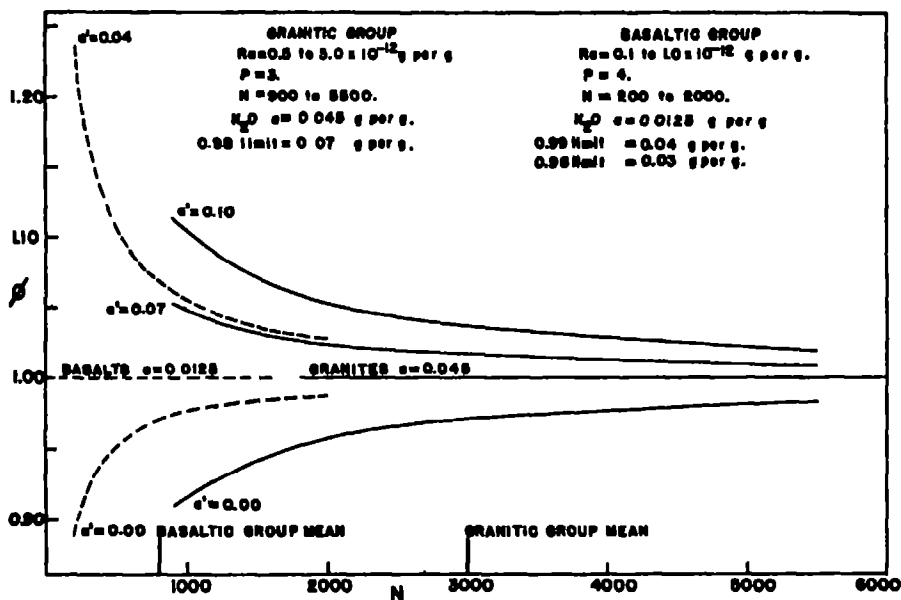
Fig 1 —-The uncertainty ratio ϕ as a function of the alpha-particles emitted per hour, N, for the granitic group as defined in the text, with rhyolites and aplites (solid curves) and for the group of basalts, gabbros, and diabases (dashed curves)
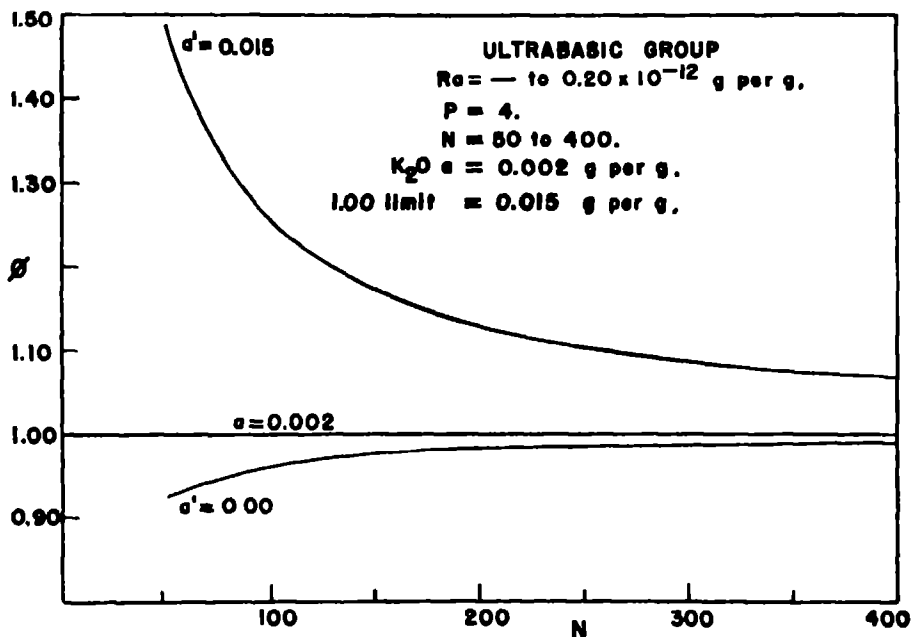
Fig 2 —The uncertainty ratio ϕ as a function of the alpha-particles emitted per hour, N, for the ultrabasic group of rocks defined in the text

A survey of the uranium and thorium contents of all types of igneous rocks indicates that the rate of production of heat may vary by a factor of 30 or more among individual specimens. Since these variations in a single type-group even when taken from a very restricted area often exceed 25 percent, the method outlined above for determining the heat production with a single measurement and an assigned value for the potassium is sufficiently accurate. Figs. 1 and 2 indicate that an uncertainty exceeding such variations from specimen to specimen is not likely to occur often. A similar treatment for the sedimentary rocks awaits a statistical analysis of the potash distribution.

RADIOACTIVE PRODUCTION OF HEAT IN THE PAST

The rate of production of heat by radioactive processes must be continuously decreasing, as is demonstrated by the fundamental law expressed by the equation

$$dn/dt = -\lambda n, \qquad (15)$$

where n is the number of atoms present at any time. The rate of production of heat will be higher but will fall off more rapidly, the greater the value of the disintegration constant λ. Prior to the direct methods employed by Nier[11] to determine the value of λ_{AcU}, some values were proposed that would indicate a considerably greater rate of production of heat in the early stages of the earth's history than at present. Similarly, the contribution from potassium was assigned a more conspicuous place in the early history of the earth. Recent determinations of the radioactive constants result in much lower values of the ratio of the rate of production of heat in the past to that at present. Thus the curves in Fig. 3 show this ratio to be between 1.33 and 1.56 at 2×10^9 years ago. To obtain a higher ratio one can invoke unknown radioactive elements or series that are supposed to have disintegrated to a concentration at present not detectable. Such elements or series of elements can only have influenced the rate of production of heat for a comparatively short period in the earliest history of the earth, or have been present in prodigious quantities and initially have generated heat at a rate greatly in excess of the production from uranium. Since this point does not seem to have been appreciated by those who have suggested such a source of energy in pre-Cambrian times, it is treated in an appendix.

The ratio of the rate of production of heat at a given time T in the past to that at present $(\overline{H}_T/\overline{H})$ can be expressed as a function of two

[11] NIER, A O   Phys Rev 55: 150   1939
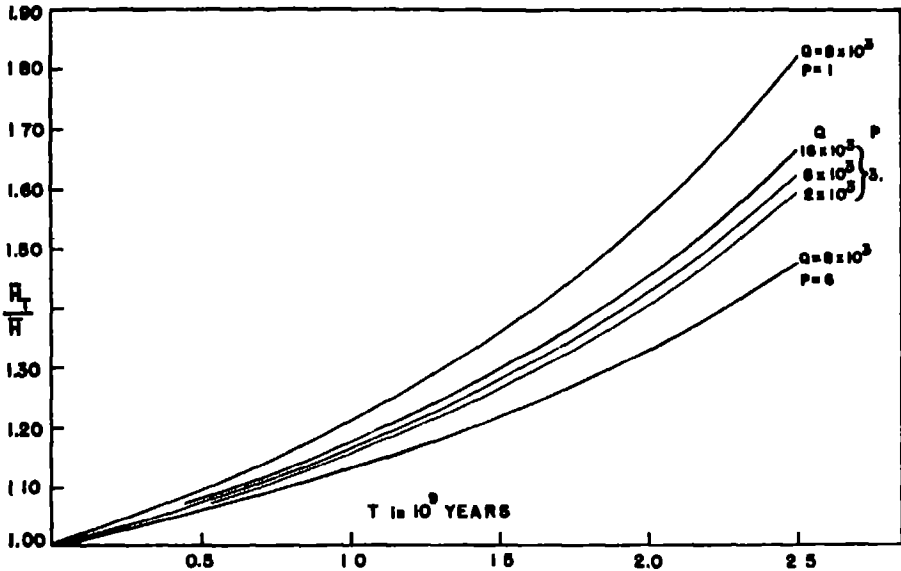
Fig 3 —The ratio of the rate of production of heat, from all the known radioactive sources, in the past to the value at present, (H_T/H), as a function of time T in the past

variables P, the thorium to uranium ratio, and Q, the potassium to uranium ratio.

Integrating equation 15, we obtain

$$(N_{UI})_t = N_{UI}e^{\lambda_{UI}t} \tag{16}$$

and corresponding equations for the AcU and Th series and for the potassium. The rate of production of heat at any time t will then be given by

$$h_{UI}\frac{d(N_{UI})_t}{dt} = h_{UI}\lambda_{UI}N_{UI}e^{\lambda_{UI}t} \qquad \text{etc.} \tag{17}$$

The concentrations of the four radio-elements can be considered as constant over a period of one year; therefore

$$\frac{d(N_{UI})_t}{dt} = \frac{\Delta(N_{UI})_t}{\Delta t} \tag{18}$$

where $\Delta t =$ one year.

Analogous to equation (3),

$$N_K = 6\ 089QfN_U \tag{19}$$

The total heat production per year at time t is determined by summing the terms (equation (17) for the three series and potassium,-

after expressing N_{UI}, N_{ACU}, N_{Th}, and N_K in terms of N_U with the aid of equations (3), (4), (5), (6), and (7).

$$\bar{H}_t = \frac{N_U}{1+k} [h_{UI}\lambda_{UI}e^{\lambda_{UI}t} + kh_{AeU}\lambda_{AeU}e^{\lambda_{AeU}t} + h_{Th}\lambda_{Th}(1+k)1.026Pe^{\lambda_{Th}t} \tag{20}$$

$$+ h_K\lambda_K(1+k)6.089Qfe^{\lambda_K t}] \tag{20}$$

The ratio $(\bar{H}_T/\bar{H})$ is then given by

$$(\bar{H}_T/\bar{H}) = [\text{Expression}, t = T]/[\text{Expression}, t = 0], \tag{21}$$

in which only two independent variables P and Q appear.

The value of P has been discussed already. Uranium averages can only be given for two large groups of rocks and these averages depend somewhat on the critical weighting of the literature by the computer. The calculation of Q is shown in Table 3.

TABLE 3 —POTASSIUM-URANIUM RATIO

Group	Radium $\times 10^{12}$ g/g	Uranium $\times 10^6$ g/g	K₂O (mode) g/g	K (mode) g/g	Q
Granitic	1 6	4 7	0 045	0 037	7 9 ×10³
Basaltic	0 4	1 2	0 0125	0 010	8 3 ×10³

That one might expect to find Q roughly constant is borne out by the conclusions of Poole and Joly[12] and of Holmes[13] and by the observations of Rössner[14] and of Evans and Williams[15] "that the radium increases with the alkalies, especially with potash," but Barth[16] finds no evidence to substantiate this correlation in the Finnish Granites. Comparatively large variations of Q between individual specimens and even local areas are to be expected. Figure 3 indicates no significant difference in $(\bar{H}_T/\bar{H})$ for values of Q between 2 and 16×10^3 and that the maximum increase in the radioactive output of heat 2×10^9 years ago compared with the present is 56 percent with a most unlikely value of P. A more probable value is 43 percent falling to 17 percent at 1×10^9 years ago. A discussion of the significance of this result is beyond the scope of this presentation.

SUMMARY

It has been shown that the determination of the quantity of heat generated by the disintegration of the radio-elements in the materials

[12] POOLE, J H J, and JOLY, J   Phil. Mag (6) 58: 819   1924.
[13] HOLMES, A   Geol Mag 63. 306   1926
[14] RÖSSNER, H.   Mineralog petrog. Mitt 44: 494.   1933
[15] EVANS, R D, and WILLIAMS, H   Amer Journ Sci. 29: 441   1935
[16] BARTH, T F W.   Amer Journ Sci 35A 231   1938.

of the earth's crust can be made by a single physical measurement for the majority of laboratory specimens. A large number of measurements are necessary, and too few are available, because of the complexity of older methods. A moderate degree of accuracy is sufficient, since variations among individual specimens are large and such variations can be studied and treated only with a volume of data. The analysis of this method indicates that an uncertainty of less than 5 percent is introduced by a lack of knowledge of the exact value of the Th/U ratio. If the potassium content is not measured the uncertainty increases to possibly 15 percent. The probable error, including the errors of measurement, is less than 25 percent except in a few isolated cases of relatively high potassium content and very low uranium and thorium values such as may be encountered in a few ultrabasic specimens.

The ratio of the rate of production of radioactive heat in the past to the present is very important in a consideration of geothermal problems. No equation for determining this ratio seems to have appeared in the literature. The ratio is relatively insensitive to a choice of the two independent variables, and guidance in their choice is afforded by the available radioactive measurements. No significant increase in heat production within the structure of the earth during the accepted age of the earth $(2 \times 10^9$ years) may be inferred.

The possibility of the existence of radio-elements hitherto undetected is explored from the point of view of their influence on the ratio of the heat production in the past to that at present. It is concluded that such elements could contribute an appreciable quantity of heat only before 1.5×10^9 years ago.

APPENDIX

The problem is to explore the possibility of the existence of radio-elements that have so far escaped detection but that contributed a considerable quantity of heat to the rocks of pre-Cambrian times $(10^9$ to 2×10^9 years ago). The existence of a series, analogous to the uranium I series, which produces at least the same quantity of heat per disintegration of the unknown parent as does UI, is the most favorable assumption. If this unknown series (subscript x) is to contribute θ times the heat contribution of the uranium I series, T years ago, then from equation (17),

$$h_x N_x \lambda_x e^{\lambda_x T} = \theta h_{\mathrm{UI}} N_{\mathrm{UI}} \lambda_{\mathrm{UI}} e^{\lambda_{\mathrm{UI}} T}. \tag{A}$$

If the unknown parent x is an isotope of uranium, Nier finds the upper limit of abundance relative to U-238 to be at the most 1/12,000 for

APPENDIX TABLE —VALUES OF θ AND THE RATE OF PRODUCTION OF HEAT IN THE PAST RELATIVE TO THE PRESENT FOR VARIOUS CONSTANTS FOR AN UNKNOWN RADIOACTIVE SERIES

α	10,000				2,000				∞
λ_x year^{-1a}	6.3×10^{-9}		4.5×10^{-9}		5.0×10^{-9}		3.6×10^{-9}		0
T years	θ	$\dfrac{H_T{}^b}{H}$	θ	$\dfrac{H_T}{H}$	θ	$\dfrac{H_T}{H}$	θ	$\dfrac{H_T}{H}$	$\dfrac{H_T{}^c}{H}$
0×10⁹	0.004	1.0	0.003	1.0	0.016	1.0	0.012	1.0	1.0
1.0	2.0	2.3	0.23	1.3	2.0	2.3	0.36	1.4	1.17
1.5	44	29	2.0	2.6	22	15	2.0	2.6	1.28
2.0	967	667	18	14	245	170	11	9	1.43

^a Calculated from the *italicized* values with equation B
^b From Fig. 3, P=3, Q=8×10⁵, with the heat contribution from the x-series added
^c From Fig. 3, P=3, Q=8×10⁵, no x-series

mass numbers 242 to 231, exclusive of the known isotopes 235 and 234.[17] If the parent x is not an isotope of uranium, its limit of abundance could hardly be greater than 1/2,000 relative to U-238, otherwise alpha-particles or beta-rays should be detectable. Substituting for the following examples, $h_x = h_{UI}$ and $aN_x = N_{UI}$, equation A becomes

$$\lambda_x c^{\lambda_x T} = \theta a \lambda_{UI} c^{\lambda_{UI} T}. \tag{B}$$

By assigning θ a given value for a chosen value of T, e.g., 2.0 at 10⁹ years, equation B can be solved for λ_x, and θ determined for other values of T. These values are given in the Appendix table with the values of (H_T/H) calculated for the additional heat from the x-series. Obviously the value of (H_T/H) in column 10 can not even be doubled at 10⁹ years without an absurd value of (H_T/H) at 2×10⁹ years (columns 3 and 7). The case for doubling the rate of production of heat at 1.5×10⁹ years is more favorable (columns 5 and 9) although the values of $(\overline{H}_T/\overline{H})$ still increase considerably at 2×10⁹ years and are only slightly greater than the value without the x-series at 10⁹ years. The most favorable case is for $a = 2,000$, $\lambda_x = 3.6 \times 10^{-9}$ yr^{-1}, but the alpha-particle activity ratio of the unknown parent to that of UI in this case would be 1.2 percent, and the series should have been detected. Thus an appreciable increase of the heat ratios in Fig. 3 due to an undiscovered radioactive series and, to a much greater extent an undetected single radio-element, must be confined to a period before 1.5×10⁹ years, that is, very early in the history of the earth; otherwise the birth-stage of the earth would be accompanied by excessive production of radioactive heat.

[17] NIER, A. O.   Phys. Rev. **55**: 150   1939

CHEMISTRY.—*The use of chloroform to accelerate cyanogenesis in the analysis of cyanogenetic plants.*[1] J. F. COUCH and R. R. BRIESE, U. S. Bureau of Animal Industry. (Communicated by H. W. SCHOENING.)

In 1909 Guignard (5, 6) reported that when leaves or other tissues of cyanogenetic plants are subjected to cold or to certain anesthetics like ether or chloroform there is an increase in the rate at which hydrocyanic acid is evolved. Mirande (7) applied this discovery in modifying Guignard's picric acid paper test for the detection of cyanogenetic compounds in plants. Armstrong and his coworkers (1) developed and refined the technique applying the test to a large series of plants. Boyd and coworkers (2) used chloroform to accelerate cyanogenesis in their method for the rapid determination of HCN in Sudan grass. This technique has the disadvantage that the chloroform distills with the HCN and clouds the distillate, which obscures the end point in the subsequent titration with silver nitrate.

A rapid process for the estimation of potential HCN in cyanogenetic plants is desirable. At present none of the available methods, with the exception of the mercuric-chloride process (3), is free from large errors. Much of the inaccuracy is due to slow development of the maximum HCN, while at the same time appreciable loss of HCN occurs through its conversion into other substances (4). Loss of HCN may be prevented by the use of mercuric chloride, but this substance considerably retards the analysis by inhibiting the enzyme.

A comparative study of the rate of cyanogenesis in water with and without the addition of chloroform was made. The figures obtained by the slower mercuric-chloride method were used as controls. Sorghum varieties grown at the Arlington Experimental Farm of the U. S. Bureau of Plant Industry under controlled conditions were available through the courtesy of Dr. J. H. Martin, of that Bureau. Samples were collected at 8.30 A.M. each morning. The entire plant of young first or second growth sorghums was used, but in the case of more mature plants the stalks were discarded and the leaves only were used. Fruiting heads, when present, were discarded with the stalks.

Samples from young plants were sliced in small pieces with a sharp knife. The leaves of older plants were hashed through a meat chopper (3). In both cases the comminuted mass was thoroughly mixed and 50-g samples were weighed out for analysis as rapidly as possible. The samples for water and for chloroform treatment were weighed

directly into 5-liter pyrex flasks and the water or water-chloroform mixture was added. One of the chloroform-water mixtures was immediately connected to a condenser and heat was applied. Fifteen minutes elapsed on the average before distillation commenced, and therefore these samples are reported in the table as being macerated one-fourth hour. Similar samples were tightly stoppered and incubated at 37° for 24 hours before analysis. Other samples were incubated with water for 24 and 48 hours at 37°. Samples for mercuric-chloride treatment were handled as previously described (3).

Twenty-four collections of seven representative sorghum varieties were used in these experiments. Nine samples were of second-growth plants, and three were of suckers. The remaining 12 samples were leaves of first-growth plants.

The results are presented in Table 1. In one case, that of second-growth Sharon kafir, the quarter-hour maceration with chloroform and the mercuric-chloride samples gave the same figure for HCN, within the limits of experimental error. In all other cases the chloroform samples gave smaller figures than the standards and in many cases so far below as to demonstrate the inadequacy of chloroform to give accurate results. In 5 cases out of 14 where the samples were macerated 24 hours the chloroform figures were lower than those for water alone. In 5 out of 13 cases they were lower than the figures for 48-hour water maceration. It appears that chloroform applied in this way can not be depended upon to give accurate as well as rapid results.

A few experiments were performed to test the utility of Roe's method for amygdalin (8) when applied directly to the plant. Samples weighing 25 g were mixed with 1 cc of chloroform, placed in a small desiccator arranged so that air might be drawn through the mass and thence conducted through a solution of potassium hydroxide to catch the entrained HCN. Before entering the desiccator the air was drawn through a scrubber containing potassium hydroxide. After several hours the cyanide trapped in the absorption apparatus was titrated according to Liebig-Denigès. A new absorption train was connected to the desiccator and air was drawn through long enough to make the total aeration period 10 to 24 hours. The results are presented in Table 2 and are compared with the results obtained after maceration of another sample in water at 37° for 24 hours. The standard is the figure obtained by the mercuric-chloride process. In one case only, that of Sharon kafir, the chloroform sample gave a figure in excess of the water-macerated sample. In all instances the results of the

TABLE 1 —HYDROCYANIC ACID RECOVERED FROM SORGHUMS AFTER MACERATION IN WATER WITH AND WITHOUT THE ADDITION OF CHLOROFORM COMPARED WITH A STANDARD BASED ON PRESERVATION IN MERCURIC CHLORIDE

Date	Variety	Stage of growth	Part of plant	Height	How prepared	Moisture	Hydrocyanic acid per 100 g calculated to dry plant				
							Stand-ard	After maceration in—			
								Water for—		Water and chloroform for—	
								24 hrs	48 hrs	15 min	24 hrs
1939				*inches*		*Percent*	*Mg*	*Mg*	*Mg*	*Mg*	*Mg*
July 17	Hegari	First	Leaves	24	Ground	70 70	208	140	188	145	
18	Sumac sorgo	Suckers	"	10-14	Sliced	84 03	180	148	130	111	
19	Sharon kafir	First	"	24-26	Ground	82 54	85	61	50	52	
20	Spur feterita	Suckers	"	20-22	"	85 15	273	256	256	216	
24	Hegari	First	"	24 26	"	81 96	284	139	151	176	
25	Sumac sorgo	"	"	36	"	81 79	184	131	141	114	
26	Sharon kafir	"	"	38 40	"	79 73	89	76	61	66	
28	Atlas sorgo	"	"	48	"	82 70	88	72		50	
31	Hegari	"	"	48	"	78 21	246	207	190	150	158
Aug 1	Hegari	Suckers	"	18	"	83 90	257	160	228	182	210
2	Sumac sorgo	First	"	72	"	80 12	152	119	116		89
3	Spur feterita	"	"	54	"	78 71	256	210	201	169	201
4	Dwarf Yellow milo	"	"	36	"	79 21	144	115		87	101
7	Hegari	"	"	60	"	78 57	225	184	194	148	172
8	Hegari	Second	Whole	10-12	Sliced	89 29	405	324	304	308	345
8	Sharon kafir	"	"	10-12	"	88 42	196	139	136	198	156
15	Ajax	"	"	6-8	"	88 10	583	444	502	481	563
22	Hegari	"	"	10-12	"	87 00	325	316	102	251	
29	Dwarf Yellow milo	"	"	12-14	"	92 55	318	227	221	170	
September 26	Spur feterita	"	"	6 10	"	87 68	238	217	198	188	219
October 10	Hegari	"	Leaves	54-60	Ground	72 97	114	47	91	54	65
11	Ajax	"	Whole	8 12	Sliced	83 44	228	163	152	133	196
16	Hegari[1]	First	Leaves	60-72	Ground	71 00	75	53	50	22	63
17	Hegari[1]	Second	Whole	8-12	Sliced	84 86	297	198	208	176	213

[1] Frosted

aeration process were much below the standard. Even with a sample of wild-cherry leaves (*Prunus serotina*), a species in which cyanogenesis is much more rapid than in sorghum, the aeration process yielded less than 50 percent of the standard. Adding small quantities of water to the plant mixtures did not improve the evolution sufficiently to make the process suitable as an accurate analytical procedure.

The reason for the failure of the aeration method lies in the slowness of cyanogenesis under the experimental conditions. Roe obtained excellent results with amygdalin and emulsin in solution, a condition in which the glucoside and enzyme may readily come into contact. In hashed plant tissues, even where the permeability of the cell wall is increased by chloroform, it is more difficult to bring the glucoside

TABLE 2 —HYDROCYANIC ACID RECOVERED FROM CYANOGENETIC PLANTS BY THE AERATION PROCESS

Date	Variety	Height	Moisture	Hydrocyanic acid per 100 g calculated to dry plant			Remarks
				After macera-tion in water for 24 hours	After aera-tion with CHCl₃	Stand-ard	
1938		*inches*	*Percent*	*Mg*	*Mg*	*Mg*	
September 26	Hegari	72	72 71	26	19	32	Leaves
28	Sharon kafir	12 14	86 41	76	82	110	Second growth
October 3	*Prunus serotina*		57 75	454	259	555	Leaves
17	Spur feterita	10–12	85 0.1	154	67	208	Second growth
5	Spur feterita	8–14	81 33	104	46	210	"

and enzyme into contact. The addition of 10 to 20 parts of water and maceration at 37° for 24 hours seldom develop the maximum quantity of HCN potential in the plant. This is due to a combination of factors, but adsorption of the enzyme on the plant fiber and consequent inhibition of contact with the glucoside appear to play an important rôle in this respect.

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PALEONTOLOGY.—*Paleocene mammals from the Denver Basin, Colorado.*[1]   C. LEWIS GAZIN, U. S. National Museum.

The untiring search by Dr. Roland W. Brown, of the U. S. Geological Survey, for Paleocene mammal remains in the Denver Basin resulted during the field seasons of 1939 and 1940 in the discovery of certain materials indicative of Paleocene age. The specimens are of a rather fragmentary nature, but their occurrence at strategic localities warrants a somewhat more detailed description than might otherwise have been given. The localities involved are of historic importance in the Cretaceous–Tertiary boundary controversy, and the mammals herein described, together with the previously known occurrences of dinosaur materials, serve to determine this boundary or greatly to restrict the known limits of its possible position in this region.

The two principal localities are the small but conspicuous area of exposure on the southeastern portion of South Table Mountain (Fig. 1), near Golden, Colo., and in an amphitheater of badlands called Corral Bluffs, east of Jimmy Camp Creek, about 14 miles east of Colorado Springs. The writer visited the region of the second locality in 1932 in the company of L. W. Nicklaus, of Colorado Springs, and the South Table Mountain with R. W. Brown in 1940.

The South Table Mountain materials are, as determined by Brown, from SW ¼ NW ¼, sec. 31, T. 3 S., R. 69 W., in the lower part of the Denver formation, about 50 feet above the highest occurrences of dinosaur materials in the same formation. The section at this locality may be seen from a distance to include a lower dark zone, a middle light-colored band, and an upper dark band, including the basaltic lava cap of the mesa. Brown has found that the lower part of the exposed section, entirely within the Denver formation, includes about 21 feet of drab-green andesitic sandstone with dinosaur and turtle remains, capped by a 3-foot bed of drab conglomerate. Fifty feet above this and about 225 feet below the basalt the mammalian remains occurred, together with specimens of the typical Denver flora, in a light, sandy clay bed of the middle light-colored zone. Hence the Cretaceous–Tertiary transition is seen to occur within the lower part of the Denver formation, between the dark dinosaur-bearing deposits and the mammal and plant horizon in the light, sandy clay zone. The boundary is considered by Brown to be at about the base of the light-colored middle zone (see Fig. 1).

Fig 1 —Exposures on southeast face of South Table Mountain, near Golden, Colo
The man stands at the place where the jaw of *Baioconodon denverensis* was found   The
arrows indicate the position of the Cretaceous–Tertiary boundary as interpreted by
R W Brown   Photograph by Brown

The mammalian materials from South Table Mountain include a
lower jaw fragment with two teeth, herein described as representing
a new genus and species, *Baioconodon denverensis*. The form appears
most closely related to lower Paleocene creodonts and seems beyond
reasonable doubt to be Paleocene in age. Two other lower jaw por-
tions, with teeth not preserved or too worn for certain recognition,
are tentatively referred to this form. A fourth small jaw fragment with
most of two premolars preserved, but well worn, may represent an
anisonchine periptychid.

The South Table Mountain Paleocene fauna as known may be
listed as follows:

Reptilia:
    Allognathosuchus sp.
    Compsemys sp
    Trionychid sp.
Mammalia:
    Baioconodon denverensis, n. gen. and sp.
    Periptychid? sp.

The crocodile teeth and fragments of turtle shell were identified by

C. W. Gilmore, of the National Museum. These are of a highly frag-
mentary nature and apparently of little or no stratigraphic signifi-
cance.

The Tertiary in the region east of Colorado Springs, in the vicinity
of Corral Bluffs and Jimmy Camp Creek, has produced, in addition
to undetermined turtle fragments, three mammal specimens. A speci-
men collected by R. W. Brown and C. E. Staudte at Corral Bluffs to
the east of Jimmy Camp Creek is the most readily identified and in-
cludes upper and lower jaw material with teeth. It is referred to the
Puercan species *Conacodon entoconus* (Cope).[2] The specimen was
found in the northeast "corner" of the "amphitheater" on the saddle
of a long spur projecting southward toward State Highway 94, in
SW¼NE¼ sec. 6, T. 14 S., R. 64 W. The lower Paleocene age of the
specimen is evident, and this horizon, identified by Brown as high in
the lower part of the Dawson Arkose, is closely related in time to the
Puerco of New Mexico. The mammal level was determined by Brown
to be approximately 100 feet above the dinosaur bearing beds farther
west on Jimmy Camp Creek.

A specimen found by Richardson,[3] and identified by Gidley as a
creodont tibia of Eocene age, came from farther west near Jimmy
Camp Creek, SW¼ sec. 2, T. 14 S., R. 65 W., 600 feet above the base
of the Dawson Arkose. Brown has checked this locality and finds that
no dinosaur-bearing strata outcrop in this section and that the tibia
comes from about 100 feet above the dinosaur material reported by
W. T. Lee,[4] roughly equivalent to the level of the *Conacodon* jaws in
Corral Bluffs. The creodont tibia is not in the collections of the Na-
tional Museum; however, the fact of its being a tibia suggests that no
accurate diagnosis was feasible, other than an early Tertiary age.
Hence, a Paleocene age seems entirely possible. Gidley's statement,
of course, did not preclude the possibility of such an age assignment
because at the time of Richardson's folio, 1912, the U. S. Geological
Survey did not recognize the term Paleocene.

From the evidence of this mammalian material, particularly the
Conacodon jaws, together with the known occurrences of dinosaur re-
mains, it is concluded that the Cretaceous–Tertiary boundary here
comes high in the lower part of the Dawson Arkose, at an horizon
that, according to Brown, is near the base of the zone of workable
coals, between 500 and 600 feet above the base of the formation.

[2] See W D Matthew   Trans Amer Philos Soc, n s, 30: 145–149, fig 30   1937
[3] G B Richardson   Bull Geol Soc Amer 23: 272   1912   Also, U S Geol.
Surv Folio 198: 8   1915
[4] W T Lee   Amer Journ Sci (4) 35: 531   1913

The specimen found by L. W. Nicklaus in the Corral Bluffs apparently comes from a somewhat lower level than the *Conacodon* jaws and constitutes further evidence for the presence of a large creodont in the Dawson Arkose.

The materials from the Dawson formation east of Colorado Springs may be listed as follows:

Reptilia:
    Champsosaurus?[5] sp.
    Testudinate remains
Mammalia:
    Creodont, near *Eoconodon heilprinianus* (Cope)
    Creodont, undet.
    Carsioptychus?[5] sp.
    Conacodon cf. *entoconus* (Cope)

In addition to the above occurrences mention may be made, as a matter of record, of a small mammal jaw without teeth, which, together with turtle remains, was found by Brown in 1940 near a coal mine in sec. 2, T. 9 S., R. 62 W., about 3.3 miles west of Norton, Colo., and east of Castle Rock. The specimen may be from a Paleocene mammal, though certainly not determinable, and comes from the upper part of the lower Dawson. The form is near the size of *Ellipsodon lemuroides*, and as in most species of that genus, it had its third molar reduced in size, as indicated by the root portions of the teeth.

CREODONTA

Baioconodon,[6] n gen.

Generic characters —Trigonid of lower molars moderately elevated, with paraconid lingual and well defined. Ridge extending anterolingually from hypoconid joins posterior wall of trigonid at distinctly lingual point. M_3 unreduced, with hypoconulid crenulate and talonid basin exhibiting rugae. External cingulae developed

Genotype —*Baioconodon denverensis*, n sp

Baioconodon denverensis, n sp

Type —Portion of right ramus of mandible with M_2 and M_3. U. S. N. M no. 16621.

Horizon and locality.— Denver formation, lower Paleocene, South Table Mountain, near Golden, Colo., in SW¼ NW¼ sec. 31, T. 3 S., R. 69 W.

Specific characters.—Size much smaller than *Eoconodon heilprinianus*, near that of *Loxolophus priscus*. Specific characters not otherwise distinguished from generic characters.

Description.—The jaw fragment of *Baioconodon* is not greatly different in

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[5] Additional materials collected by R W Brown and the writer on June 5, 1941, from the Dawson Arkose at Corral Bluffs include specimens tentatively identified, while in the field, as *Champsosaurus* and *Carsioptychus* The reptilian form is represented by several vertebrae and the periptychid mammal by fragments of a right lower jaw with only the root portions of the teeth from P₄ to M₃ and a separate right lower jaw fragment with one of the premolars preserved *Champsosaurus* is known from several Paleocene occurrences and *Carsioptychus* is characteristic of the Puercan stage of the Paleocene

[6] *βαιός*, small, + *conodon*, as in *Eoconodon*

size from that of *Loxolophus priscus*, much smaller than in *Eoconodon heilprinianus*, which it more closely resembles in the structure of the molars. The talonid portion of M_2 is about the same width as the trigonid, and having about the same anteroposterior extent. M_3 shows almost no reduction in size from that of M_2, and the talonid portion is a little longer and narrower than the trigonid. The trigonid portions of both teeth are elevated with respect to the talonids, but apparently a little less so than observed in some material of *Eoconodon*. The paraconid of both molars is well defined, lingual in position, and rather sharply distinct from the metaconid. The talonid portion is well basined and exhibits a distinct hypoconid, entoconid, and hypoconulid, the well-developed posterior crest or hypoconulid on M_3 being

Fig 2 — *Batoconodon denverensis*, n gen and sp   Portion of right ramus of mandible with M_2 and M_3, U S N M no 16621, type specimen, lateral and occlusal views ×3   Denver Paleocene, Golden, Colo   Drawing by Sydney Prentice.

somewhat crenulated. The basin of M_3 is further characterized by sharp crests, one long and one short, extending into the basin posterolingually from the ridge anterolingual to the hypoconid. The principal character of the talonid portion of the molar is the markedly lingual point at which the crest extending anterolingually from the hypoconid joins the trigonid portion of the tooth, this being a noticeable distinction when comparison is made with material of *Loxolophus*, and is most closely approached in the large *Eoconodon*. The two lower molars of *Batoconodon denverensis* are also characterized by a prominent external cingulum which shows a conspicuous cusp between the protoconid and hypoconid, especially in M_2 where it extends inward noticeably between the principal outer cusps.

The anteroposterior diameters of M_2 and M_3 are 6 8 and approximately 8.5 mm., and their greatest transverse diameters about 6 and 5.6 mm, respectively.

In comparison with material of *Loxolophus*, M_3 in *Batoconodon denverensis* is seen to be less reduced in size. The paraconid occupies a more lingual position in both M_2 and M_3 and the talonid portion in M_2 appears relatively shorter anteroposteriorly. The crest extending forward from the hypoconid

joins the trigonid at a much more lingual position, and the external cingulum is better developed than in any of the *Loxolophus* material examined.

Baioconodon denverensis is considerably smaller than *Eoconodon heilprinianus*, and the paraconid on the last two molars is relatively better developed, higher, and more distinct from the metaconid. The trigonid, though elevated with respect to the talonid, is relatively not so high as in teeth of *Eoconodon* showing comparable wear. M_3 in *Baioconodon denverensis* is a little larger with respect to M_2, and also shows a somewhat more complex talonid portion than in *Eoconodon heilprinianus* M_3 seems slightly more reduced in *Eoconodon gaudrianus* (Amer. Mus. no. 3400) but much more reduced in *Goniacodon*.

Two other specimens from the same locality on South Table Mountain, exhibiting greater portions of the mandible, but with the teeth broken off or too badly worn for certain recognition, may also represent *Baioconodon denverensis*, although there is no certainty that they do. No. 16622, a right mandibular portion possessing only the root portions of P_4 to M_3, is of a little greater size than the type, and the masseteric crest does not extend so far forward, although the roots of the teeth have the same shape and proportions as in no 16621. If the two are conspecific, the edentulous jaw may well be from a much older individual, as the teeth in the type are but very little worn.

No. 16624 is a left mandibular ramus, exhibiting root portions of the teeth from the canine to M_3. The molars have their crowns partially preserved but so badly worn as to be unrecognizable. Much of the wear on these and the root portions of the preceding teeth may have been largely erosion post mortem. The jaw itself is a little more slender below the molars than either no 16621 or 16622, but the depth is intermediate between the two. The teeth, however, appear to have been slightly smaller than in either and the root portions of M_1 relatively a little narrower, perhaps more indicative of *Loxolophus*, which it may well represent, although the root portions of the premolars suggest that these teeth may have been relatively wider and more closely spaced than in material of *Loxolophus* at hand.

Creodont, near **Eoconodon heilprinianus** (Cope)

A fragment of a left ramus of the mandible with an almost unworn lower molar, U. S. N. M. no. 16626, was found by L W. Nicklaus, of Colorado Springs, in the bluffs near Jimmy Camp Creek east of Colorado Springs The form represented, clearly a large creodont, is apparently of the triisodontine or possibly arctocyonine type. The molar is of about the size of M_1 in *Eoconodon heilprinianus* but is a little shorter and wider It rather noticeably resembles lower teeth of this form in the characters of the cusps. The outline of the tooth suggests that it may be a first lower molar, but the cusps or pattern of the trigonid more closely resembles M_2 in *E. heilprinianus* The trigonid is less elevated, but the paraconid is decidedly forward and lingual in position as in that form The talonid portion is relatively shorter and wider than in *Eoconodon* and the basin is correspondingly wider, but the crest extending anterolingually from the hypocone joins the posterior wall of the trigonid at a position almost as lingual as in *Eoconodon*, much more so than in *Claenodon*

The specimen seems to represent neither *Protogonodon* nor *Claenodon*, as indicated by characters of both the trigonid and talonid of the tooth, but may be from a form of *Eoconodon*, however, because of the somewhat more brachydont trigonid portion, it is not regarded at present as certainly representing a species of that genus.

CONDYLARTHRA

Conacodon cf. entoconus (Cope)

Portions of both maxillae with several well-worn cheek teeth and a left ramus of the mandible with P_3, P_4, and the three molars, all belonging to the same individual, U. S. N. M no. 16625, were found by Brown and Staudte east of Jimmy Camp Creek, about 14 miles east of Colorado Springs and in the Dawson formation (SW¼NE¼ sec. 6, T 14 S , R. 64 W) The form is a periptychid condylarth and apparently represents the species *Conacodon entoconus*. The teeth are rather well worn but not so much so as to leave any doubt as to the affinities of the form The development of the premolars as indicated in the right maxilla and lower jaw is in a stage equivalent to that seen in Puerco material, and the teeth in general are entirely comparable, except for a little greater width of the lower molars than in any of the Puerco material at hand. The upper molars may also have been relatively wide, but all these are damaged along the outer wall, and this, together with the sloping character of inner wall, prevents accurate measurement.

Periptychid? sp.

A small fragment of a lower jaw, no. 16623, with one complete premolar, P_3 or P_4, and half of the preceding tooth, both well worn, was found by Brown at the South Table Mountain locality The specimen appears to be of a periptychid type of mammal, and the development of the premolars is about intermediate between the Puercan forms *Hemithlaeus kowalevskianus* and *Conacodon entoconus*. Although well worn, the extent of the talonid portion on each tooth can be ascertained, and this seems more nearly equivalent to that in *Hemithlaeus*, not so reduced as in *Conacodon*, although the premolars as a whole approach in size those of *Conacodon entoconus*. The specimen was found in close association with no. 16622, referred tentatively to *Batoconodon denverensis*, but because of duplication of parts, it can not belong to the same individual. These may well be premolars of *B denverensis*, as indicated by the size of the roots, but the crown portions are suggestive of an anisonchine periptychid rather than a creodont

PHYTOPATHOLOGY.—*An evaluation of the results of treatments given narcissus bulbs for the control of the nematode* Ditylenchus dipsaci *(Kühn) Filipjev.*[1] B. G. CHITWOOD, U. S. Bureau of Plant Industry, and F. S. BLANTON, U. S. Bureau of Entomology and Plant Quarantine.

Hot-water treatment of narcissus bulbs for the control of the bulb and stem nematode, *Ditylenchus dipsaci* (Kühn) Filipjev, was inaugurated by Ramsbottom[2] and Van Slogteren.[3] In order to protect narcissus plantings in this country from this pest imported and domestic bulbs have been subjected to hot-water treatment. Originally this treatment consisted of the exposure of bulbs to hot water at 110°F. for 3 to 4 hours. Failure of such treatments to control the disease adequately was responsible for the instigation of further experimental work. As a result of this work a pre-soak of the bulbs for 2 hours in water at 70 to 80°F. was added to make the treatment more effective. Later it was suggested that the treatment bath itself might be improved by the addition of formalin. Vapor-heat treatments were also proposed as a substitute for hot-water treatments, because the latter promoted the growth of fungous diseases.

The data included herein are the result of work during the years 1931–1939 by Messrs. Spruijt, Thorne, Blanton, and Chitwood; Miss E. M. Buhrer; and Mrs. Grace S. Cobb. The writers have assembled these data according to treatment, year (except table 2), and technic of handling.

There are two possible objectives in the treatment of plants for the control of parasites: (1) Eradication of or cure from infestation; (2) reduction of infestation. Since none of the known treatments indicate probable attainment of the first objective, this paper is concerned with the reduction of infestation. This may be approached either from the standpoint of (*a*) the reduction in number of living specimens in each plant or (*b*) the reduction in number of infested plants. Treatments acceptable for one purpose may be of no great value for the other purpose. This seems to be the case in daffodil bulbs infected with the bulb and stem nematode, *Ditylenchus dipsaci*. Since a male and a female of this species could theoretically produce 200,000 off-

spring in 90 days, it seems doubtful that mere reduction in numbers of living nemas would be of any real benefit. Moreover, reduction in numbers of nemas for each bulb would not reduce the number of foci of infestation in the field.

Inconsistent results have been a feature of all experimental work involving the determination of nemic mortality. The literature is extensive, but the particulars are not especially informative. In general, experimental work has been conducted in two manners. One method has been to treat infected stocks and make field observations the following year. This method has not been productive, since sometimes the symptoms appear to be suppressed the year following treatment and to reappear later. The other method has been to treat one or more known infected bulbs at each of a number of durations and temperatures and later to determine the percent nematode revival in them. This method does not take into consideration the natural variation in biological data. In this paper only those records showing complete mortality in a given bulb are given consideration. Much of the data was obtained prior to realization of the necessary requirements. However, since these data show that many treatments commonly thought to be of value are not satisfactory, we feel they are worthy of recording. The writers have applied, for the first time, statistical methods for the evaluation of treatments of bulbs for the control of the stem and bulb eelworm and have found that one can now predict, with reasonable assurance, the efficacy of treatments.

RESULTS FOR THE YEARS 1931–1938

The data are presented in tabular form, the hot-water and modifications of the hot-water treatments applied in the years 1932 1938 constituting table 1, and vapor heat and its modifications for the years 1931–1938 constituting table 2 In both tables each block contains two numbers, the first representing the number of examinations in which one or more living nemas (*D. dipsaci*) were found, the second representing the number of examinations in which specimens of *D dipsaci* were found either living or dead. The number of bulbs in each examination varied from 1 to 30 A single record of "no living" *D. dipsaci* in a treatment is not evidence that this treatment is satisfactory, since sometimes the same treatment at greater duration or a similar treatment at higher temperature contains living specimens Undoubtedly several records of no living specimens would be necessary before a treatment could be considered satisfactory, since a few records might be due to chance. Sometimes other species of nemas remain alive in bulbs in which all the *D. dipsaci* are apparently dead Such species include *Aphelenchoides parietinus* (Bastian) Steiner, *Aphelenchus avenae* Bastian, *Cephal-*

obus spp., and *Panagrolaimus subelongatus* (Cobb) Thorne; these cases are marked by an asterisk. Often no nemas were observed in washings of chopped treated bulbs, either because they were absent or because it is often difficult to establish the presence of *D. dipsaci* in bulbs receiving satisfactory or near-satisfactory treatment even when they are present; examination of the data has shown that if it were assumed that absence of nemas indicated a kill, one would be in error nearly half the time Consequently, such records (0–0) can not be used. A single examination based on two or more bulbs should be of more value than an examination based on one bulb. Since it is impossible to state either what proportion of the bulbs was actually infected before treatment or, if living *D dipsaci* are present, in what proportion all the nemas were killed, each record as given in tables 1 and 2 must be interpreted as a single observation Thus a record of 0–1 indicates one observation in which all specimens of *D. dipsaci* were found dead, regardless of number of bulbs in the given sample, while 5–10 indicates 10 observations covering 10 samples in which specimens were identified living or dead and 5 samples in which they were found living, regardless of number of bulbs in each sample.

The treatment dates of the various years were as follows:

1 *Vapor heat* —Sept. 16–28, 1931; Sept. 7–14, 1932; Sept 8–13, 1933; July 26 to Sept. 13 (weekly), 1934; Oct 9–14, 1936, and Sept 21–26, 1938 The series of vapor heat treatments in 1934 were made for 3, 4, and 5 hours, duration at three temperatures, 114, 116, and 118°F., one sample at each temperature and duration was treated each week during the period. The total numbers of samples providing living *D. dipsaci* on these dates were 5, 6, 5, 9, 5, 9, 8, and 5 out of a possible 9 for each respective week.

2. *Hot water* - -Sept 7 14, 1932, Sept. 20–23, 1933, Oct 9–14, 1936; Sept 14–16, 1938

The average number of bulbs constituting a single sample for each of the years was as follows· 1931, vapor heat 1, 1932, vapor heat and hot water 1.4; 1933, vapor heat 1 1 and hot water 3.7; 1934, vapor heat 4.4; 1936, vapor heat 1.5 and hot water 1.9, 1938, vapor heat and hot water 12.

The results of the 1931 and 1932 vapor-heat treatments were published by Sprujt and Blanton.[4] They are included here for the sake of completeness.

Since tests on the permeability of nemic membranes[5] had indicated a relative impermeability of nemic membranes at room temperature, special tests were conducted in 1938. In these tests infected bulbs were soaked in 0.75 per cent and 0.5 per cent formalin at room temperature and served as a basis for the following records respectively (presented as in tables 1 and 2): 2 hours 1–2 and 2–2; 4 hours 2–2 and 4–4; 6 hours 2–2 and 4–4. Infected bulbs soaked in a 1 per cent solution of formalin at room temperature gave the following results. 24 hours 3–3, 48 hours 3–4, 72 hours 3–4; 96 hours 0–2. From these results, formalin at room temperature is obviously ineffec-

[4] Journ Econ Ent 26(3)· 613–620, tables 1–3   1932
[5] CHITWOOD, B. G   Proc Helm Soc Washington   5(2) 68–75   1938

TABLE 1 —EFFECT OF HOT-WATER AND ITS COMBINATIONS ON THE CONTROL OF THE BULB AND STEM NEMA, DITYLENCHUS DIPSACI (KÜHN) FILIPJEV

Year	Type of treatment‡	Temp	1	2	3	4	5	6	7	8	9	10	11	12
		°F												
1938	Hot water	104	3-3	13-13		13-13		6-8		7-13				
1938	Formalin (1 199)	104	6-6	12-14		5-10		2-6		2-17				
1938	Formalin (1 99)	104		2-2		2-3		2-2		1-3				
1938	Hot water	110	7-9	10-14		5-16		0-1		0-11				
1936	Hot water—Presoak	110			1-1	1-1	0-1	0-0	0-1	1-1	1-1	0 1		
1938	Hot water- Presoak	110		1-1		1-2		2-2						
1938	Formalin (1 199)	110	6-8	0-14		1-21		0-5		0-11				
1938	Formalin (1 99)	110		0-4		0-13		0-2		0-3				
1938	Formalin (1 199)—Presoak	110		0 1		0-1		0 1						
1936	Formalin (1 199)—Presoak	110			0-1	0 1	0 1	0-1	0-1	0-1	0-1	0-1		
1938	Formalin (1 132)	110		0-1		0-1		0 1						
1938	Formalin (1 132)—Presoak	110		0 1		0-1		0 1						
1933	Hot water	111 5				1-2	1-6	3-3	3-4					
1932	Hot water	112				0-1	0-1	0-1		0-1				
1936	Hot water—Presoak	112			1-1	0-1	1 1	0-1						
1938	Hot water - Presoak	112				1-1		0 0						
1936	Formalin (1 199)—Presoak	112			0-1	0-1	0 1	0-1						
1938	Formalin (1 199)—Presoak	112				0 1		0-1						
1932	Hot water	113			0-1	0 1	0-2	0-2	0 1	0 2	0-2	0 1	0-1	0-1
1933	Hot water	113		*0-5*	*0-5*	*0-4*	*1 2*							
1932	Hot water	114				0*1	0-1	0-0	0-1	0 1	0-0	0-1	0 1	0 1
1938	Hot water	114		1 1		*0-1*		1-1						
1938	Hot water—Presoak	114		*0-1*		0 0		1-1						
1936	Hot water Presoak	114			0-0	0-1	0 1	0-0						
1938	Formalin (1 199)	114		0*1		0 1		0*1						
1936	Formalin (1 199)—Presoak	114			0-0	0 0	0-0	0-1						
1938	Formalin (1 199) Presoak	114		0-1		0-0		0 1						
1938	Formalin (1 132)	114		0 1		0*1		0*1						
1938	Formalin (1 132)—Presoak	114		0*1		0*1		0*1						
1932	Hot water	115			0-1	0-0	0-1	0-1	0-1	0-0	0-0	0-0	0-1	0-1
1933	Hot water	115		*3-3*	*1-4*	*1-4*	*1-5*							
1932	Hot water	116			0-1	0-1								
1936	Hot water –Presoak	116			0 1	0-0	0-1	0 0						
1936	Formalin (1.199) Presoak	116			0-1	0-1	0 1	0-1						
1932	Hot water	117				0 1								
1933	Hot water	117		0 4	0-3	0-3	0 3							
1932	Hot water	118			0-1	0-1	0-0	0*1						
1933	Hot water	118			1-3	0 3	0-3	0 4						
1938	Hot water	118	6 21	0-20		0-6				0-6				
1938	Formalin (1 199)	118	0-3	0-1										
1932	Hot water	119		0-1	0-1									
1932	Hot water	120		0-1										

* Other species of living nematodes also found

† In each block two numbers are given, the first of which represents the number of examinations in which living *D dipsaci* were observed living and the second represents the number of examinations in which *D dipsaci* were observed either living or dead The *italic* numbers represent records invalidated by the observation of living nematodes in more severe treatments

‡ *Presoak* means that the treatment was preceded by a presoak in water at 70-80°F

TABLE 2.—EFFECT OF VAPOR HEAT AND ITS COMBINATIONS ON THE CONTROL OF THE BULB AND STEM NEMA, DITYLENCHUS DIPSACI (KÜHN) FILIPJEV

Type of treatment*	Temp	Duration in hours†											
		1	2	3	4	5	6	7	8	9	10	11	12
	°F												
Vapor heat	110			2-2	2-2	2-2	2-2						
Vapor heat—Preheat	110			1-1	1-1	1-1	1-1	1-1	1-1				
Vapor heat—Presoak	110			1 1	2-2	0-0	2-2	0-0	0 1				
Vapor heat - Formalin presoak	110			0-0	0-2	0-1	0-2	0-1	0-0				
Vapor heat	111			2-2	2-2	2-2							
Vapor heat	112		2-2	2 2	2-3	0-2	1-1		0-1				0-1
Vapor heat— Preheat	112			1-1	1 1	1 1	0-1	1-1	1 1				
Vapor heat Presoak	112			1 1	2-2	1-1	1-2	0 1	1-1				
Vapor heat - Formalin presoak	112			1-1	0-2	0-1	0-1	0-0	0-0				
Vapor heat	113		2-2	3-3	2-3	2-2	0-1	0 1	0-2	0-1	0-2	0 1	0-1
Vapor heat	114	2-2	2-2	10-10	8-9	7-8	0-1	0-1	0 0	0 1	0-1	0-0	0-1
Vapor heat—Preheat	114			1-1	1-1	0-1	1-1	1-1	1-1				
Vapor heat Presoak	114			1-1	0-1	0-0	0-1	0 0	0-0				
Vapor heat—Formalin presoak	114			0-0	0 0	0 0	0-1	0-1	0-1				
Vapor heat	115	2-2	2-2	0 1	0-1	0-1	0-1	0 1	0-0	0-0	0-1	0 1	0-1
Vapor heat	116			8-13	7-12	4-10	1-1						
Vapor heat—Preheat	116			1-1	1-1	0-0	0 1	1-1	0-1				
Vapor heat—Presoak	116			0-1	1 1	0-1	0-1	0-0	0-1				
Vapor heat Formalin presoak	116			0 0	0-1	0-0	0-1	0-1	0-1				
Vapor heat	117			0-2	0-3	0-3	0-1						
Vapor heat	118	1 1	1-2	4 14	5-12	4-13	0-4						
Vapor heat —Preheat	118			1-1	0-0	0 0	0-0	0-0	0-1				
Vapor heat— Presoak	118			0-0	0-0	0-0	0-0	0 1	0-1				
Vapor heat—Formalin presoak	118			0-0	0-0	0-0	0-0	0-1	0-0				
Vapor heat	119		0-1	0 3	0-1	0-3	0-1						
Vapor heat	120	1-1	1-2	0 4	0-4	0-2	0-1						

* *Preheat* means that the treatment was preceded by 2 hours of preheating at 70–80°F , *presoak*, treatment preceded by a presoak in water for 2 hours at 70–80°F , *formalin presoak*, treatment preceded by a presoak in formalin (1 100) at 70–80°F

† In each block two numbers are given, the first of which represents the number of examinations in which living *D dipsaci* were observed and the second the number of examinations in which *D dipsaci* were observed either living or dead

tive as a nematocide for nemas in bulbs Since results presented elsewhere in this paper show that formalin at higher temperature is effective, heat appears to be essential for the action of formalin on *D dipsaci* in narcissus bulbs.

DETERMINATION OF A STANDARD OF EFFICACY

The variability in efficacy of a given treatment is emphasized by the finding of living *D. dipsaci* after treatments at higher temperature, longer duration, or greater concentration of formalin than those after which no living

specimens were found. Before making a recommendation one should be able to predict the proportion of bulbs in which all specimens of *D. dipsaci* would be killed. Commercial stocks of narcissus bulbs are considered badly diseased when 5 percent are infected with nematodes. This would be 50 in 1,000. If untreated, each bulb may easily serve as a source of infection for three additional bulbs. Thus, in one year the number could increase to 200. If treated in such a manner that all the nemas are killed in 19 out of 20 infected bulbs (95 percent), then three out of 50 (6 percent) would be left infected; one might expect 12 infected bulbs in one year and 48 in two years The treatment would then have to be repeated If the original lot of 1,000 bulbs, 5 percent infected, were treated in such a manner as to kill all the nemas in 18 out of 20 bulbs (90 percent), then one might expect five bulbs (10 percent) to be left infected, which would increase to 20 in one year and 80 in two years. Hence it would be necessary to treat every year in order to reduce the infection Annual treatments being impractical, the minimum standard of efficacy should be better than 90 percent, preferably 95 percent so that a treatment is necessary only in alternate years.

The problem now is to determine how many bulbs must be examined to assure a statistically sound basis for measuring efficacy Such a basis is furnished by the binomial distribution.[6]

Let p = any assumed efficacy expressed as a proportion of 1, let q = the remainder, also expressed as a proportion of 1, and let n = the number of bulbs examined For instance, for a desired efficacy of 90 percent, $p = 0.9$, $q = 0.1$.

Then expansion of $(p+q)^n$ represents the various class frequencies expected, the first term being the proportion of zeros expected, the second the number of ones, the third the number of twos, etc

In order to predict with 19:1 probability that a treatment giving zero survival from a homogeneous lot of infected bulbs has an efficacy better than a desired efficacy p, the number must be such that $p^n = 0.05$ or less This is true because with the assumed efficacy and smaller numbers, random sampling will give zero more than 5 percent of the time and a somewhat lower efficacy will give zero 5 percent of the time. Thus with smaller numbers we will not have assurance that a zero means efficacy of p or better With larger or equal numbers such assurance is obtained. With groups of bulbs showing heterogeneity, more variation may be expected, and somewhat larger numbers might be needed.

In order similarly to predict with 19:1 probability that a treatment giving 1 survival has an efficacy better than a desired efficacy p, the number must be such that $p^n + np^{n-1} q = 0.05$ or less With still larger numbers of survivors the formula becomes increasingly complex.

Assuming an efficacy of 90 percent, a complete kill would have to be obtained in 29 bulbs. Living nemas in one bulb would have to represent 46

[6] SNEDECOR *Statistical methods*, rev ed 1938

treated bulbs; similarly two, three and four bulbs with living nemas would have to represent 61, 76, and 89 bulbs respectively. An apparently perfect treatment would not be recommendable if based on less than 29 bulb examinations.

Assuming an efficacy of 95 percent, a complete kill in 59 bulbs would be required in order to prove the treatment better than the assumed efficacy. A treatment must be considerably better than an assumed efficacy to show its superiority with a high probability statistically. As the efficacies of treatments more closely approach 100 percent one is nearly justified in accepting the actual efficacies since the numbers of bulbs must be so large.

In order to make the greatest possible use of the data available, it would appear that one is justified in selecting any given treatment and adding to its record the records of all treatments of lesser severity until one comes to a record of living nemas This is an approximate method leading only to tentative conclusions.

PERCENTAGE OF FORMALIN AND RATIO OF BULBS TO LIQUID

An experiment was designed to test the significance of the proportion of bulbs to quantity of liquid in the treating tank, the liquid varying in percentage of formalin. The percentages of formalin were 0 25, 0 5, 0 75, and 1 0, the proportions of bulbs to liquid (by weight) were 1:2 8, 1:4, and 1:5 3; treatment durations were 2, 3, 4, and 5 hours All treatments were at 110°F. with no presoak. Allowance was made for actual time required for the liquid in the treating chamber to return to 110°F after the bulbs were put in. The bulbs were medium-sized Laurens Koster Each sample contained five supposedly infected bulbs. They were held submerged by crossed garden labels. The treatments were conducted in 1-gallon cans submerged in a standard treating tank with an agitator. No agitator was present in the individual cans The temperature was taken for the cans and not the tank Treatments were conducted September 26 to 29, 1939.

The data are presented in table 3.

Totals by duration show that the 2-hour treatment (13–35) was unsatisfactory; by actual record the 3-hour treatment (4–44) was better but of questionable value; the 5-hour treatment (2–36) was still better by actual record; and the 4-hour treatment (0–42) was perfect. Since both of the bulbs with living nemas in the 5-hour treatments were in 0 25 percent formalin solutions, it is apparent that this concentration is unsatisfactory.

Totals by ratio of solution weight to bulb weight show no striking differences but the 5.3:1 ratio shows a lower survival than the 2 8:1 or 4:1 ratios.

Totals by percentage of formalin are likewise inconsistent with practically identical results with the 0.25, 0.75, and 1.0 percent solutions and poorer results with the 0 5 percent solution. However, six of the seven bulbs unsatisfactorily treated in 0.5 percent formalin were in the 2-hour duration and five

TABLE 3 —EFFECT OF HOT WATER AT 110°F ON THE CONTROL OF D. DIPSACI WITH
RELATION TO THE PERCENTAGE OF FORMALIN AND THE RATIO OF
SOLUTION TO BULBS, 1939

Solution weight	Formalin	Duration in hours†				Total‡	
Bulb weight		2	3	4	5	By ratio	By percent
	Percent						
2 8 1	0 25	0–1	0–4	0–2	1 3	1–10	
4 1	0 25	1–2	0–3	0–5	0–2	1–12	
5 3 1	0 25	1–3	0–4	0–3	1–5	2–15	4–37
2 8 1	0 5	1–2	1–4	0–4	0–4	2–14	
4 1	0 5	5–5	0–2	0–4	0–4	5–15	
5 3 1	0 5	0–1	0–3	0*4	0 2	0–10	7–39
2 8 1	0 75	0–3	1–5	0–3	0–4	1–15	
4 1	0 75	1–3	0–3	0–4	0–4	1 14	
5 3 1	0 75	0*4	2–5	0–3	0–2	2–14	4–41
2 8 1	1 0	2–3	0 3	0 3	0*2	2–11	
4 1	1 0	2–5	0–3	0–2	0–3	2–13	
5 3 1	1 0	0*3	0–5	0 5	0–1	0 14	4 38
Grand total		13–35	4–44	0–42	2–36	19–157	10–157

* Other species of nematodes
† In each block two numbers are given, the first of which represents the number of examinations in which
living specimens of D dipsaci were observed and the second represents the number of examinations in which
specimens of D dipsaci were observed either living or dead
‡ Totals by solution-bulb ratio are as follows 2 8 1, 6–60, 4 1, 9–54, 5 3 1, 4–53

were in a single treatment. This could have easily been due to error in the
treatment technique.

EFFECT OF REUSING THE SAME FORMALIN SOLUTION

An experiment was designed to test the possibilities of repeated treatments
in the same solution of formalin at 110°F. A constant volume of liquid and a
constant weight of bulbs (5 pounds, or 2.268 kg) was maintained The treat-
ing tank was a constant temperature bath with agitator This bath was filled
with 0 5 percent formalin solution to the 10.5-liter mark and refilled to this
level with 0.5 percent formalin before each repeated treatment. The solu-
tion-bulb ratio was, therefore, 4 6:1 There were six treatments of three
hours' duration and six of four hours' duration

Ten medium-sized Laurens Koster bulbs were used for each of these tests.
The treatments were conducted on October 9 to 11, 1939.

Since bulbs contain a relatively large quantity of water they would tend
to dilute the formalin solution. Theoretically, for the liquid in the bulbs to
contain the same amount of formalin as the external liquid contains, the per-
centage of formalin in the liquid would be reduced to 0 4 percent and that
in the bulbs would be raised to 0 4 percent. In order to compensate for this
reduction in concentration, in subsequent treatments sufficient formalin to
make a 0 1 percent solution was added in tests 5 and 6.

In treatment 1 fresh formalin was used while in treatments 2–6 the forma-
lin had previously been used one or more times. In treatments 2, 3, and 4 only

sufficient formalin (0.5 per cent) was added to compensate for the loss in volume due to prior use, there being no compensation for loss in concentration.

The results of this experiment are given in table 4. The minor difference in totals by duration, 2–29 for the 3-hour and 1–42 for the 4-hour treatment, might well be due to chance No reduction in efficacy appears to have occurred as a result of second and third use of the treating bath whether or not an attempt was made to compensate for dilution of the formalin. However, when the treating bath was used a fourth time without compensation the efficacy was reduced in both 3- and 4-hour durations. Even this difference might have been due to chance but it would not be wise to risk such treatments commercially

TABLE 4.—EFFECT OF REPEATED TREATMENTS IN THE SAME SOLUTION OF FORMALIN AT 110°F ON THE EFFICACY OF SUCH TREATMENTS FOR D DIPSACI

Test no	Character of bath*	Duration in hours†		Totals by treatment
		3	4	
1	Fresh	0 4	0–9	0–13
2	Second use	0–6	0–6	0 12
3	Third use	0–6	0–8	0–14
4	Fourth use	2–5	1–0	3–11
5	Second use, C	0–4	0–6	0–10
6	Third use, C	0–4	0–7	0–11
Totals by duration		2–29	1–42	

* C denotes that sufficient commercial formalin was added to compensate for theoretic reduction in concentration due to prior use of the bath

† In each block two numbers are given, the first of which represents the number of examinations in which living D dipsaci were observed and the second represents the number of examinations in which nemas were observed either living or dead

EFFECT OF PRESOAK AND VARIED TEMPERATURES, DURATIONS
OF TREATMENT, AND CONCENTRATIONS OF FORMALIN

This experiment was designed to test the difference in efficacy of varied treatments at varied temperatures. Treatments were made in a standard hot-water treating tank with an agitator. Ten bulbs, supposedly infected with D dipsaci, were used for each test. Those in tests 1 to 8, 11 to 16, and 22 were medium-sized King Alfred bulbs rogued from the fields, while those in tests 9 to 10 and 17 to 21 were mixed varieties grown normally in the field. The size of the mixed variety bulbs naturally varied; the average size, however, was approximately the size of a small round King Alfred bulb with a diameter of about one and one-fourth inches. The experiment was conducted on September 19 to 23, 1939 Results are presented in table 5.

Using totals by treatment and temperature, the percentage of efficacy favors presoak in six cases, no presoak in two cases, and is equal in three cases. From this one might presume that presoak was advantageous. However, if one makes the same comparisons by duration with a given treatment one finds, by comparing 0.5 percent formalin treatments with and without presoak, that the percentage of efficacy favors presoak in only 2 cases, is

against presoak in 3 cases and is equal in 8 cases. Presoak has no demonstrable advantage, possibly a disadvantage.

Comparing efficacy of 1 percent formalin treatments with and without presoak, 4 favor presoak, 1 is against and 4 are equal. With hot water, 4 favor presoak, 1 is against, and 7 are equal.

Using the binomial method of analysis for recommendation previously dis-

TABLE 5 —EFFECT OF PRESOAK, VARIED TEMPERATURES, DURATIONS OF TREATMENT, AND CONCENTRATIONS OF FORMALIN ON THE EFFICACY OF HOT-WATER TREATMENTS FOR D DIPSACI

No	Type of treatment†	Temp	Duration in hours‡						
			1	2	3	4	6	8	Total
		°F							
1	Hot water	110				3-7	2 4	0-8	5-19
2	Hot water Presoak	110				1-9	1-6	0-6	2-21
3	Formalin (1 99)	110	0-10	4-8	0*8		0-0		13-35
4	Formalin (1 99) - Presoak	110	3-7	7-7	0-6		0-4		10-24
5	Formalin (1 199)	110	7-0	1-7	1-6		0-0		0-31
6	Formalin (1 199) —Presoak	110	4 5	0*5	1 7		0-5		5-22
7	Hot water	114	6-7	3-9	0 9		0 7		0-32
8	Hot water —Presoak	114	6-7	0-7	1-7		0-8		7-20
9	Formalin (1 199)	114	1-2	0-2	0-4		0 3		1 11
10	Formalin (1 199)—Presoak	114	0-1	0-2	0-2		0-0		0-5
11	Hot water	116	7-8	1-7	1-10				8-25
12	Hot water—Presoak	116	2-7	0-5	0 7				2-19
13	Formalin (1 199)	116	0*8	0-0	0-8				0-25
14	Formalin (1 199)—Presoak	116	1-0	0-5	1-7				2-21
15	Formalin (1 99)	116	1-8	1-8	0 9				2-26
16	Formalin (1 99) —Presoak	116	0 10	0-3	0-8				0 21
17	Hot water	118	0-8	0-4					0-11
18	Hot water—Presoak	118	0-8	0-3					0-11
19	Formalin (1 199)	118	0-3	0-4					0-7
20	Formalin (1 199)—Presoak	118	0-5	0-0					0-11
21	Formalin (1 99) .	118	0-5	0-5					0-10
22	Formalin (1 99)—Presoak	118	0-0	0 0					0-15

* Other species of living nematodes also found

† Presoak means that the treatment was preceded by a presoak in water at 70–80°F

‡ In each block two numbers are given, the first of which represents the number of examinations in which living D dipsaci were observed and the second represents the number of examinations in which D dipsaci were observed either living or dead

cussed, the following treatments by addition are tentatively recommendable with probability of at least 19:1 that the efficacy is better than 90 percent, 1 percent formalin for 3 hours at 116°F. or 1 hour at 118°F preceded by a 2-hour aqueous presoak in either case, 1 percent formalin for 2 hours at 118°F. with no presoak; and 0 5 percent formalin for 2 hours at 118°F. with a 2-hour aqueous presoak. Only one treatment is shown with probability of 19:1 to have an efficacy better than 95 percent, this being 1 percent formalin for 2 hours at 118°F. with a 2-hour aqueous presoak. Many of the other treatments may have an efficacy as high or higher if there were sufficient data.

DISCUSSION

By combining tables 1 to 5, several recommendable treatments are obtained, these being based on bulbs of various sizes and stages of disease, and treatments in different seasons. By addition of records of treatments of lesser durations, lower temperature or lesser concentration of formalin, one treatment has an efficacy significantly better than 95 per cent, this treatment being 2 hours in 1 per cent formalin at 118°F. with a 2-hour aqueous presoak at 70° to 80°F. The tolerance of bulbs to this treatment is not known.

Similarly, by addition of records one modification of the vapor heat treatment, namely 8 hours at 118°F. with a 2-hour presoak in 0.5 percent formalin at 70° to 80°F., had an efficacy significantly better than 90 percent.

The minimum hot-water treatment that, based on addition of records, had an efficacy significantly better than 90 percent was 4 hours at 118°F.

Based on addition of records other treatments with an efficacy significantly better than 90 percent are: 1 percent formalin at 118°F. for 1 hour with a 2-hour aqueous presoak; 1 percent formalin at 116°F. for 2 hours with a 2-hour aqueous presoak.

All efficacies determined by addition of records must be considered tentative. The tolerance of bulbs is not known for any one of these treatments.

The data in tables 1, 3, and 4 on the 0.5 percent formalin treatments at 110°F. for 4 hours with no presoak are adequate to demonstrate an efficacy of better than 90 percent with no addition of records from other treatments. The tolerance to this treatment, with the addition of a presoak has been determined by Blanton and Chitwood.[7] In an experiment on 40 varieties of narcissus and 41 lots during one year the controls showed a greater weight increase in every variety, while during the next year the controls showed a greater weight increase than the treated bulbs in only 23 lots and a lesser or equal weight increase in 18 lots. The only conclusion one may draw from this information is that there is great variability in tolerance to treatment.

Regarding the efficacy of a 4-hour treatment, in 0.5 percent formalin in tables 1, 3, and 4, the records for this treatment are 1–21, 0–12, and 1–42. Adding these one obtains a record of 2–75, or an observed efficacy of 97 percent. On the basis of binomial distribution this gives a predicted efficacy of better than 91 percent. Despite the rela-

[7] Proc Helm Soc Washington 7(2) 91–94 1940.

tively small number of bulbs involved, it would appear that this treatment is recommendable.

The efficacy of a 3-hour treatment in 0.5 percent formalin is indicated by records from tables 3, 4, and 5, these being 1–9, 2–29, and 0–8, respectively. Adding these one obtains the total 3–46 or an observed efficacy of 93 percent. The predicted efficacy would be considerably under 90 percent, but more extensive records might show this treatment to be recommendable.

SUMMARY

The results of narcissus-bulb treatments for *Ditylenchus dipsaci* over a period of 9 years are presented. These treatments are all modifications of the hot-water and vapor-heat treatments.

Because of the nature of the disease producing organism, *D. dipsaci,* and its mode of spread, the authors conclude that a treatment should have an efficacy of better than 90 percent, preferably 95 percent, to be recommendable in the control of this disease.

A method of evaluating the results of treatments is given. To prove a treatment efficacy of greater than 90 percent, at least 29 records of a complete kill of *D. dipsaci* are necessary. One bulb containing living specimens must represent at least 46 bulbs containing this species of nematode to substantiate an efficacy of better than 90 percent and two, three, and four bulbs with living nematodes must represent at least 61, 76, and 89 bulbs, respectively, to corroborate the same efficacy.

Hot-water treatments have been conducted at several temperatures ranging from 104° to 120°F. A 2-hour presoak in water at 70°–80°F. appears to be of some benefit from the standpoint of nemic control. However, no hot-water treatments other than those in combination with formalin are considered both practical and recommendable.

Vapor-heat treatments have shown no particular advantage over hot-water treatments from the standpoint of nemic control. No plain vapor-heat treatment is considered recommendable on the basis of the data available. A vapor-heat treatment at 118°F. for 8 hours preceded by a 2-hour presoak in 0.5 percent formalin at 70°–80°F. is recommendable from the standpoint of control, but it is considered too drastic for host tolerance. Less severe vapor-heat treatments in combination with a formalin presoak might be recommendable were sufficient data available.

It is shown that a certain degree of heat is essential to insure lethal action of formalin on *Ditylenchus dipsaci* in narcissus bulbs. A presoak-

in a 0.5 percent formalin solution at 70°–80°F. followed by vapor-heat treatment probably has the same effect as a treatment in formalin solution at a higher temperature.

In hot-water formalin treatments the temperature showing the least bulb injury for the maximum efficacy appears to be 110°F. No benefit was apparent as a result of presoaks in combination with hot-water formalin treatments. The formalin used in these experiments ranged in concentration from 0.25 to 1.0 percent commercial formalin. Demonstrable differences in efficacy as a result of these various concentrations could have been due to chance but it would probably be safest to use not less than 0.5 percent formalin at the present time. Likewise, the differences as a result of varied proportions of bulbs to liquid could have been due to chance but it would be safest to use not less than 5.3 parts by weight of solution to 1 part by weight of bulbs. The treating bath may be used for two consecutive treatments providing enough formalin of the same concentration is added to bring up the volume. According to the present data the solution does not warrant further use thereafter.

On the basis of these data, a treatment in 0.5 percent formalin for 4 hours at 110°F. with no presoak is recommendable from the standpoint of nemic mortality. The tolerance of bulbs to this treatment is not known, but it is known for the same treatment with the addition of a 2 hours' aqueous presoak. According to this information narcissus varieties and lots of the same variety differ in their tolerance to the treatment. There is also a marked difference in the tolerance of the same stock of bulbs from year to year. In general, the increase in weight may be smaller in treated than untreated bulbs. Considering the damage inherent in the disease, treatment is not too drastic. Treatment for 4 hours in 0.5 percent formalin at 110°F. is the best treatment known today. It is recommended for all stocks containing a residuum of bulbs infected with *D. dipsaci*. A treatment of 3 hours in 0.5 percent formalin at 110°F. might be recommendable were sufficient data available.

In conclusion, the results of this work show that.

1. Estimates of efficacy should be based on binomial distribution formulae.

2. Considerable numbers of bulbs should be examined individually.

3. Hot-water and vapor-heat treatments require relatively high temperatures or long durations to be effective.

4. Hot-water formalin treatment at 110°F. for 4 hours is apparently a recommendable control measure for *Ditylenchus dipsaci* in narcissus bulbs

MYCOLOGY.—*On* Argynna polyhedron (*Schw.*) *Morgan.*[1]   G. W. MARTIN, State University of Iowa.

The fungus that is the subject of the present note was originally described by Schweinitz (Trans. Amer. Phil. Soc. **4**: 257. 1834) as *Physarum polyaedron*. His material was collected at Bethlehem, Pa., on a dead stump of *Juglans*. The species was not again noted until Morgan (Journ. Cincinnati Soc. Nat. Hist. **18**: 41. 1895) reported it from Ohio, on hickory. Morgan had recognized his collection as probably referable to the species described by Schweinitz and had sent a portion to Dr. G. A. Rex, who compared the two and pronounced them identical. Since it could not be a *Physarum* and the spores were unlike those of any known fungus, Morgan erected for it the new genus *Argynna*, so called because of the butterfly-shaped spores. Although he saw no asci, he was convinced that the spores could have been borne in no other way and that the genus was to be included in the Perisporiaceae. His drawings represent the spores accurately and also show correctly the small, nearly globose fructifications, without ostioles and with walls composed of brittle, carbonaceous, hexagonal plates.

Von Hohnel (Ann. Myc. **15**: 361. 1917) accepted Morgan's decision that *Argynna* was an ascomycete but decided that Morgan had incorrectly described the spores and that they must in reality be 1-celled, with membranous wings, as in *Samarospora* Rostrup. Von Hohnel included *Argynna* with *Cephalotheca*, *Zopfiella*, and other genera in his new family Cephalothecaceae, segregated from the Perisporiaceae by possession of an outer wall composed of angular plates. Theissen and Sydow, writing in the same volume (Ann. Myc. **15**: 466. 1917), summarily dismiss the genus with the remark that it can not be considered an ascomycete. There is not the slightest suggestion that any of these European mycologists ever saw the fungus; hence their cavalier treatment of Morgan's description must have been based entirely on preconceived ideas of what the genus ought to be like. Nevertheless, Theissen and Sydow's dictum is accepted by Clements and Shear (Gen. Fungi 255. 1931). The change in the spelling of the specific name from *polyaedron* to *polyhedron*, first made by Saccardo, may not be technically valid but is in accordance with the practice suggested by Recommendation 38 of the present rules.

In April, 1939, a third collection of the species was made at Big Spring, Mo., on an old and much-decayed log of some frondose species. An attempt to culture it proved successful; it will grow on all—

ordinary laboratory culture media and has produced cleistothecia on sterilized cornstalks, on oak twigs, and, more sparingly, on oat agar. *Argynna polyhedron* is unmistakably an ascomycete, to be assigned to the Perisporiaceae or, if von Höhnel's family is to be recognized, to the Cephalothecaceae. The spores are 2-celled, exactly as Morgan described them. The septum is somewhat obscured by the very dark central portion of the mature spores (Fig. 1, *d*, *g*), but less mature spores, while still in the ascus (Fig. 1, *f*) show it clearly. Morgan's
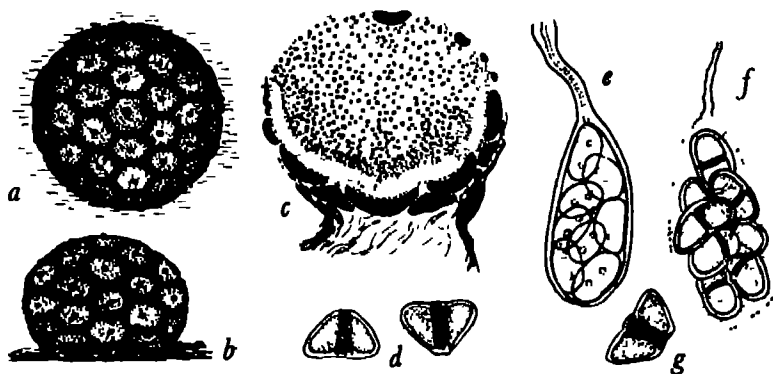
Fig 1 —*Argynna polyhedron* (Schw) Morgan *a*, Large ascocarp, from above, ×24, *b*, smaller ascocarp, on subiculum, from side, ×24, *c*, longitudinal section through large ascocarp on stalklike stroma, showing basal plates, hymenium, and spore mass, ×24, *d*, two spores from Morgan's Ohio collection, ×1,200, *e*, immature ascus with distinct wall and spores as yet unseptate, ×1,200, *f*, mature ascus with wall gelatinizing and spores septate and becoming dark, ×1,200; *g*, mature spore from Missouri strain, ×1,200

recognition of the nature of the spores is completely justified and the summary and arbitrary decision of Theissen and Sydow is proved to be without warrant.

The cleistothecia are nearly globose, sessile on a flattened base and fuscous-black under a lens, appearing black to the naked eye. In culture they are often borne on a dense, dark subiculum (Fig. 1, *b*) and in some cases this may form a thick, stalklike base (Fig. 1, *c*). Such a subiculum is not apparent in the two field collections available but is represented by the intense blackening of the substratum in Morgan's collection but not in the Missouri collection from which the cultures were derived. Morgan gives the diameter of the cleistothecia as 1–1.5 mm, which is correct for his material. Those of the Missouri collection and the cultures derived from it are distinctly smaller, 0.3–1.3 mm in diameter, mostly 0.5–1 mm.

The asci are borne in a dense palisade layer lining the lower portion

of the cleistothecium (Fig. 1, *c*). They are at first clavate with a rather thick wall and a slender stalk, the spore-bearing portion 18–22×8–10μ, and contain eight spores. As they mature the spores become septate and darken. Simultaneously the stalk shrivels, the ascus walls become gelatinized, and the spores are set free in the gelatinous matrix above the hymenial layer, apparently completing the process of maturation in the cleistothecial cavity after leaving the asci. Dehiscence is by the separation of the plates of the peridium, beginning at the top and exposing the dark brown spore mass in a cuplike cavity.

ENTOMOLOGY.—*Some new species of Syrphidae from South America.*[1] FRANK M. HULL, University of Mississippi. (Communicated by EDWARD A. CHAPIN.)

In this paper I present the descriptions of several new syrphid flies from South America, most of which have come to hand in the past few years. Several of these have been collected by John Lane, of São Paulo, Brazil. Types, unless otherwise stated, are in the collection of the author. Paratypes where present have been deposited in the collection of Mr. Lane.

Mesogramma mulio, n sp

Related to *norma* Cur and *productus* Cur., but there are pairs of small detached spots on the third and fourth abdominal segments, this pattern is much like that of *planiventris* Lw., but *mulio* is much larger, the abdomen slenderer, etc.

Male. Length 7.5 mm. *Head* Cheeks, face, and front wholly pale yellow, the latter with a tiny, median impression, the facial sides white-pubescent. The antennae are light orange, the third joint barely brownish above, the face quite produced forward and pinched Vertex brilliant violet behind ocelli, golden between them, the occiput brassy-brown pollinose, its pile wholly light yellow *Thorax.* Mesonotum dark olive-brown, the sides broadly yellow, becoming a little darker above the wing and on the postcalli Down the middle of the mesonotum is a diffuse, pale, steel-bluish, brownish-yellow pollinose, somewhat diffuse vitta that runs all the way to the scutellum. The dark mesonotal disk where it meets the yellow side margin is dark, brownish-black, vittate. Pleurae metallic black, the humeri, propleurae, posterior two-thirds of the mesopleurae, upper portion of sternopleurae all pale yellow, which last section is also densely, silvery pubescent. The scutellum is deep brownish yellow, with subappressed blackish pile and two longer marginal black bristles near the middle and a long, well-developed golden ventral fringe. *Abdomen:* Elongate with parallel sides from the middle of the second segment almost to the middle of fourth, deep brownish yellow marked with black as follows: A posterior fascia along the margin of the first segment, narrowed in

the middle, slightly expanded on each side but not reaching the sides of the segment. There is a parallel-sided, narrow, basal fascia on the second segment, a wider one on the posterior margin which is evanescent on the posterior half, which reaches the lateral margin and is slightly wider there. On the third segment there are similar fasciae, the basal one considerably more evanescent and the posterior one not quite so distinct. Fourth segment similar to the third except that the basal fascia leaves only traces widely separated on either side. Both of these segments have faint, medial, approximated, linear, sublunate vittae whose anterior ends turn outward and are knobbed. Fifth segment with a linear, median, black vitta two-thirds the length of the segment. Hypopygium yellowish brown with black spots. The abdominal pile is black, except on the base of the first segment, its sides, the extreme corners of the second, and a few hairs on the corners of the fifth segment. Legs: Pale yellow, the hind femora with a distal smoky annulus, their tibiae with a middle annulus. Pile of legs yellow except on whole distal half of middle femora, base of their tibiae as far as the middle ventrally, whole of hind tibiae and their femora except the base and dorsal surface of the hind tarsi, which are all black pilose. Wings: Hyaline, the stigma brown.

Holotype: One male, São Paulo, Juquia, Brazil, J. Lane, collector.

Mesogramma gemini, n. sp

Related to duplicatus Wied., but the face is much shorter, the abdominal pattern different.

Female. Length 5 5 mm. Head· Face yellow, the antennae orange, the third joint blackish above, the front widely black, the sides narrowly yellow. Thorax. Mesonotum broadly olive-brown pollinose, with a wide steel-blue medial linear vitta; the lateral margins are obscurely brownish yellow. Scutellum wholly yellowish brown, long, sparse, black pilose, the propleura is dark. Abdomen. Oval, the sides conspicuously emarginate, dark yellowish brown, marked with black as follows: All but the anterior corners and lateral margins of the first segment, the wide marginal fasciae on the base and apex of the second segment, each occupying about a third the length of the segment. The third and fourth segments are each marked alike—there is a wide, black, posterior, marginal fascia occupying two-fifths of the length of the segment. There is also a very narrow submedial and sublateral, basal, marginal fascia, and the intervening yellowish-brown area contains a pair of narrowly separated, small triangles, which are connected to the posterior fascia by slender linear vittae, the spaces between the posterior fasciae indented. Fourth segment with a large, opaque, black, medial, basal spot, the posterior margin of the segment narrowly shining black as well as the posterior half of the lateral margin. Legs: Light yellow, the hind tarsi blackish above throughout, the hind tibiae and apical half of hind femora appearing darker because of the black pile. Wings. Hyaline, stigma pale brown.

Holotype· One female, São Paulo, Brazil, March 22, J. Lane, collector.

Mesogramma flamminea, n. sp.

Related to M. basilaris Wied., but the face almost wholly yellow, scutellum yellow marginate, abdominal pattern different.

Male. Length 4.5 mm. Head: Face, front, and antennae yellow, the arista brownish, the vertex blackish and feebly shining, black pilose. Thorax: Mesonotum broadly shining metallic, dark brown-pollinose with a brownish median vitta, the narrow lateral margins, the humeri and propleurae pale yellow. Scutellum metallic greenish black, the margin broadly brownish yellow.

Abdomen: Narrowly oval, shining, reddish brown All the first segment except the anterior corners and a narrow anterior margin, shining black; this black extends diffusely onto the basal fourth of the second segment. The abdominal pile is short and black, the reddish hypopygium chiefly pale pilose, with a diffuse blackish spot on the left side. *Legs·* Light yellow; the hind femora has a conspicuous, subapical, black annulus. The hind tibia has a subbasal annulus; much of the tibial and femoral pile is golden. Hind metatarsi black on the basal half, their last two tarsal joints black; intervening joints brown. *Wings:* Hyaline, the stigma pale yellow.

Female Similar, the face brownish yellow, barely darker in the middle. Abdomen yellow with conspicuous, posterior, black, marginal fasciae, there are posterior black corners that extend laterally up most of the length of the segment and in some cases completely along the lateral margin The second segment has a basal and a medial fascia dividing the yellow Third and fourth segments with a pair each of small, narrowly separated comma-like spots

Holotype: One male, São Paula, Severinia, Brazil, A G. Silva, December 1940. Allotype. One female, same data in the collection of John Lane Paratypes: One male and female in copula, seven males and one female (four male paratypes in the collection of John Lane), same data.

Volucella calochaeta, n sp.

Related to *prescutellaris* Will, but the front as well as the face is light brownish yellow.

Male. Length 9 5 mm. *Head·* Eyes exceedingly densely light brown, long pilose. Cheeks (except for a very diffuse narrow brown vitta), face, and front light brownish yellow. Frontal pile and an extensive patch covering the low broad tubercle and vertical pile black; elsewhere the pile is pale The face is considerably produced both downward and forward. The antennae are elongate, light orange, the pale arista has 32 rays above *Thorax·* Broadly coppery-violaceous in the middle with a greenish cast, the sides broadly yellowish brown, the propleurae, mesopleurae, and humeri yellowish brown and golden pilose, the remainder of the pleurae darker brown, almost black in places with yellowish pile There is a single, heavy, tuberculous bristle on the upper part of the mesopleurae, three on the notopleurae, three above the base of the wing, three on the postcalli, six pairs on the scutellum, all of which are quite long There are some finer, long, black bristles before the scutellum; the mesonotal pile is pale yellow with a few black hairs. Scutellum yellow, with long, fine black bristly pile and yellow ventral fringe. *Abdomen.* Chiefly brown to black, marked with a pair of large, basal and lateral brownish-yellow spots on the sides of the second segment, diffusely separated by brown in the middle and on the sides of the third segment a pair of almost equally large, basal, pale yellow spots widely separated by black in the middle. The first segment is light brownish; the fourth segment is very dark brown, black on the apical margin, the hypopygium yellow The pile of the posterior third of the the first segment and narrowly up its middle is black The pile of the third segment is black on almost the posterior half, on the black middle vitta, and on a portion of the yellow on each side of this, and there is a narrow basal fringe of black pile on this segment. The remainder of the yellow spots are yellow pilose. Basal two-thirds of the pile of the fourth segment yellow, the remainder black. *Legs* Dark brown, the hind tibiae and tarsi and the anterior tibiae and tarsi much darker, almost black, the pile of legs everywhere black *Wings:* costal and subcostal cells upon their basal half, first and second sub-

basal cells yellowish The marginal and submarginal cells are brownish. The marginal cell is closed in the costa on one side, opened on the other.

Holotype: One male, received many years ago in some miscellaneous material from Brazil, no further data

Volucella azurina, n. sp

Related to *mexicana* Macq. but equipped with four prescutellars and scutellum with five pairs of heavy bristles Related also to *fulvicornis* Bigot, but the face is dark brown, the abdomen is blue, there are also scutellar differences, etc

Female Length 13 mm *Head:* Cheeks black, face and front and vertex reddish brown, the front a little darker. The face is considerably produced downward and forward; the tubercle is moderately prominent, deeply excavated above but continued almost straight downward from the tubercle to the epistoma The pile of the face, front, and vertex is black, the face with considerable whitish pubescence throughout but more extensive on the flattened area below the antennae The sides of the front are also whitish pubescent. The antennae are orange-brown, the third joint about twice as long as wide, the apical half a little narrower than the basal part, and a little darker dorsally and apically; the arista is pale yellow, with 30 rays above *Thorax:* Mesonotum and pleurae shining blackish, the former with slight purplish cast, the sides of the mesonotum also dark The pile of the entire thorax and scutellum including its fringe is black with the exception of whitish pile on the anterior portion of the mesopleurae, the humeri, and some in the anterior middle of the mesonotum. The mesopleura has three rather long, heavy, tuberculous black bristles, notopleura with five, base of wing with three, postcalli with five, and scutellum with six pairs The scutellum itself is dark, shining, mahogony, reddish brown. *Abdomen:* Very broad and rounded, the disk only gently convex and entirely metallic, purplish black throughout over which is a strong bluish reflection, its pile is black, dense, short, and stubby upon second and third segments and much longer and sparser upon the fourth segment. *Legs:* Black and black-pilose, the apex of the anterior femora the base of their tibiae dark brown. *Wings.* Dark brown upon the basal anterior half, including first and second basal cells and a slight marginal area posterior to the latter and distal to the former. The marginal cell is well closed, its apex not expanded

Holotype. One male, Bonito, Brazil Received several years ago in miscellaneous material from Brazil, no further data

Ceriogaster aureopila, n sp

Related to *auricaudata* Will., but the mesonotal sutures bordered with short golden pile and without opaque black marginal spots. Apex of abdomen appressed golden pilose Scutellum blackish

Female Length 6.5 mm. *Head:* Eyes with a median transverse impressed line just above the middle Vertex blackish about occlli behind the vertex and occiput is metallic brassy black, which from an oblique view is yellow-pollinose The lower half of the front is more or less light yellowish-brown pubescent. On each side of the bare facial carina is a narrow vertical stripe of light-colored pubescence, and there is a similar one along the angular anterior margin of the check. Antennae elongate, the third joint three times as long as the second, the entire antennae and arista pale yellowish brown. Back of upper occiput with black spines. *Thorax:* A row of spines lies across the anterior part of a mesonotum; just back of the spines is a dull, yellowish

transverse fascia of pubescence that appears almost golden in places and throughout which arises some very short golden pile The fascia is well interrupted in the middle There is a similar interrupted fascia lying along the anterior suture continued down over the upper part of the mesopleura upon its posterior margin. Just before the scutellum there is a more obscure fascia or subtriangular spot Scutellum dark black with very short black pile, the posterior margin dull brassy. *Abdomen.* Club shaped, the first two segments not greatly narrower than the decumbent club-shaped third and fourth segment Sides of the first segment steel blue, becoming brassy at the extreme margin. Second segment extensively black throughout the middle, with a faint metallic luster, along the lateral margin becoming bright and coppery and brassy All the third and fourth segments golden with coppery luster, except for a large, somewhat opaque, blackish triangle in the middle of the second segment, the base of which lies along the posterior margin of the segment. Pile of the last two segments flat, appressed, everywhere bright golden, dense, and directed diagonally toward the midline from each anterior corner The middle pile, however, directed straight backward. *Legs.* Femora dark brown, almost black on the basal half of the pair, with a somewhat metallic luster that in places grows decidedly brassy. Pile of the legs everywhere pale yellowish, except upon the anterior surface of the fore tibiae and all their tarsi. Hind femora rather thickened, its ventral margin with a double row of black spines, which reach almost from apex to base Fore tarsi black and rather flattened, the other tarsi and tibiae light yellowish brown, the hind pair somewhat pale at base *Wings:* Tinged with brown, the apical third obliquely rather smoky, the stigmal cell smoky brown

Holotype· One female, Barro Colorado, Panama August 1938, F. M Hull, collector

ENTOMOLOGY.— *Description of a new bat bug (Hemiptera-Heteroptera. Cimicidae).*[1] HARRY G. BARBER, U. S. Bureau of Entomology and Plant Quarantine.

Recently Drs. Glen M. Kohls and William L. Jellison, of the U. S. Public Health Service at Hamilton, Mont., submitted for determination a number of specimens of a new bat bug which were collected in the Ney Cave, near Hondo, Tex. With the permission of the collectors a description of this new form is herewith presented.

Primicimex, n gen.

Head longer, than wide, impunctate, somewhat longer than pronotum, strongly convex and setose above and beneath, eyes small in both dorsal and lateral view, projecting, remote from anterior angles of pronotum; tylus broad; jugae short, antenniferous tubercles prominently visible from above, maxillary lobes well developed; antenna with the first two elongate segments incrassate, subequal, last two segments slender, rostrum short, stout, not surpassing base of head. Pronotum longer than wide; anterior and posterior margins concave, fringed with long setae, lateral and posterior edges narrowly margined and fringed with long setae. Hemelytra orbicular, expanded laterally, in contact behind scutellum, roughly rugose, surface and margins with long setae. Scutellum wider than long. Abdomen of male asymmetrical;
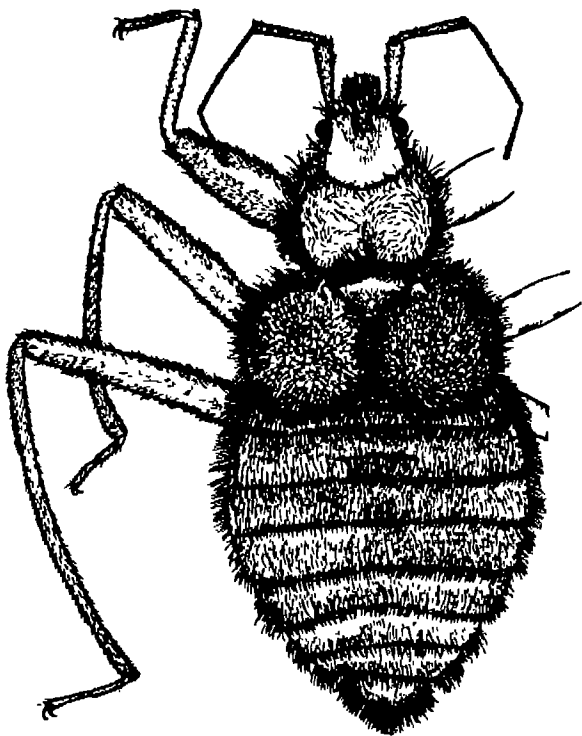
Fig 1 —*Primicimex cavernis,* n gen and sp

left paramere forming a long, curved, acute process; right paramere aborted. Metasternum elevated. Legs long mutic, setose; anterior femur more incrassate than other femora, all tibiae long and gently curved.

Genotype.—*Primicimex cavernis,* n sp

Primicimex is apparently a primitive member of the Cimicidae, presenting no close structural relationship to any known cimicid genera. The most remarkable characteristics are the relatively long head, orbicular hemielytra, and the elongated legs which resemble those of certain reduviids.

Primicimex cavernis, n. sp.   Fig 1

Color brownish, hemielytra and legs somewhat paler; last two segments of antenna, rostrum, apex of scutellum, and tarsi stramineous. Body and appendages profusely setose. The setae are of two kinds, setiform on the ventral parts and on the appendages, while most of those on the dorsum are cylindrical, curved, very minutely serrate on the convex side, and with the apices delicately spurred.

Head impunctate, shining, longer than wide (1 44 by 1.32 mm), strongly transversely convex both dorsally and ventrally; preocular margins to apices of antenniferous tubercles 0.28 mm. long, slightly diverging anteriorly, shorter than postocular margins, which gradually diverge posteriorly; setae longer and denser beneath; eyes relatively small, viewed dorsally about one-third longer than wide, seen laterally but little higher than wide; tylus broad, a little wider anteriorly and widest just before the middle, subtruncate at apex, strongly transversely convex; jugae short, apposed to sides of tylus and

extended anteriorly nearly as far as apices of antenniferous tubercles; antenniferous tubercles broad and short, obliquely truncate at apices; base of labrum visible from above; maxillary lobes extended anteriorly from apices of jugae to just beyond apex of tylus, the edges fringed with short setae; two long, erect setae on each side of head, one before front line of eyes, midway between these and tylus, the other lateral, behind eye. Antenna rather long, about one-third longer than head and pronotum conjoined; first two segments incrassate, with short, inclined setae, basal segment porrect, slightly curved, a little shorter and wider than second, extended beyond apex of head by more than half of its length; last two segments much more slender, filiform, sparsely and finely setose, terminal segment shortest, gradually and slightly expanded apically, appearing truncate at apex, lengths of the respective segments as follows: I, 1.00; II, 1.12, III, 1.44, and IV, 0 80 mm. Rostrum short, stout, nearly or quite attaining base of head, second segment slightly longer than basal segment, terminal segment short

Pronotum nearly one-third wider than long, subshining, impunctate, rather strongly transversely convex, densely long setose; anterior and posterior margins concavely emarginate, lateral margin gently and almost evenly rounded; lateral and posterior submargins deeply and narrowly impressed, the external edges roundly elevated, forming calloused margins, the curved setae along margins as well as those on anterior region longer than elsewhere on surface Scutellum triangular, wider than long, disk rather flat, margins deflexed, apex bluntly rounded Hemielytra orbicular, opaque, roughly rugose, surface with rounded shallow pits, exposed margins densely fringed with long curved setae, the surface with shorter curved setae

Abdomen broadly oval, asymmetrical posteriorly in the male; tergites closely rugose punctate, covered with short recumbent setae, in the male the setae along the margins as well as on the surface much longer and more erect; terminal segment densely set with long setae; left paramere long, gently curved, falciform, grooved along upper face, right paramere aborted. Metasternum elevated. Legs long, densely covered with short, recumbent setae, tibiae gently curved, hispidlike, and faintly conspurcated. Anterior femur shorter and more incrassate than other femora, concave below toward base, lower surface as well as coxa and trochanter beneath densely setose, anterior tibia shorter than femur, with a padlike calcarium at apex; anterior tarsus nearly half as long as tibia, basal segment short, terminal slightly longer than intermediate segment, claws well developed; intermediate femur a little shorter than tibia; posterior femur longer than other femora, tibia longer than femur. Length of male, 10 mm.

Type material.—Type, male, from Ney Bat Cave, near Hondo, Tex , collected on October 14, 1940, by Drs Glen H Kohls and William L. Jellison. Collection No. A. P. 17258

Paratypes, 2 males, 11 females, and numerous nymphs, with same data.

Type and paratypes in the U. S. National Museum (no. 55230). Paratypes in the laboratory of the U. S. Public Health Service, Hamilton, Mont. One paratype, female, same locality, February 5, 1939, no 17798, collected by K. E Stager, Allan Hancock Foundation, University of Southern California.

Remarks.—Dr. Kohls writes that "the Ney Cave harbored a very large colony of the Mexican free-tailed bat, *Tadarida mexicana* (Saussure). The bugs were not actually collected from the bats but were found on the guano and rocks on the floor and also on the walls near the entrance, as well as back in the farther recesses of the cave where the rocks were wet and the atmosphere approaching saturation."

ARCHEOLOGY.—*Prehistoric Eskimo harpoon heads from Bering Strait.*[1]   HENRY B. COLLINS, JR., Bureau of American Ethnology.

The harpoon with which the Eskimos capture seals, walruses, and other marine mammals is a complicated device consisting of a wooden shaft, a detachable head of bone or ivory, and a foreshaft, socketpiece, and ice pick of the same materials. Regional differences may be observed in all parts of the harpoon, but especially in the detachable head, which strikes and holds the quarry. Because of their complex form and the many developmental changes they have undergone in the past, harpoon heads have proved to be extremely useful in determining culture sequences in the Eskimo area.

On the basis of material excavated from five old village sites of different ages on St. Lawrence Island, Alaska, the writer has described the harpoon heads of the Old Bering Sea, the oldest Eskimo culture of which we have full knowledge, and traced their development into the Punuk, protohistoric, and modern stages. Among the specimens found at the oldest site (the Hillside site) was a broken harpoon head (Fig. 6) that did not fall into any of the established types. On the chance that it might have been an individual variation of no typological significance, it was described and illustrated but was not included in the classification (Collins, 1937, p. 107, pl. 23, fig. 8). Later, when examining archeological material collected in 1926 by Dr. Diamond Jenness on Little Diomede Island in Bering Strait, the writer saw four more harpoon heads of this type. The fact that they were deeply patinated and different in form from any known modern or prehistoric Diomede type suggested that they were older than the other objects in the collection. The same type of harpoon head has been found in considerable numbers at Okvik, an old buried site discovered by Otto W. Geist, of the University of Alaska, on Punuk Island, off the eastern end of St. Lawrence Island, and it appears again at the old Ipiutak site at Point Hope on the Arctic coast discovered in 1939 by Dr. F. G. Rainey of the same institution (Rainey, 1941).

The Ipiutak, Okvik, and Hillside sites are the oldest thus far discovered in the Eskimo area. Unlike most old Eskimo settlements, they were completely buried and were unknown to the local Eskimos. Ipiutak is culturally the most divergent and seemingly the earliest of the three sites. It lacks certain features common to the other two and

in addition has a number of unique elements. On the other hand, a definite cultural interrelationship between the three sites is indicated by close correspondences in some of the implements and in the style of art, which the writer has described as Old Bering Sea style 1 (Collins, 1937, pp. 40–47, 53–56). The occurrence of this particular type of harpoon head and of Old Bering Sea style 1 art on Little Diomede Island points to the existence of the same early stage of Eskimo culture at Bering Strait, midway between St. Lawrence Island and Point Hope. The harpoon heads referred to are clearly one of the oldest known Eskimo types, and as such it seems desirable that they should be described.

Photographs of three of the Diomede Island specimens, kindly furnished by Dr. Diamond Jenness, of the National Museum of Canada, are shown in Figs. 1–3. Drawings of another Diomede head appear in Fig 4. These four harpoon heads, and a fifth fragmentary specimen of the same type not illustrated, were excavated by Eskimos and sold to Dr. Jenness. Consequently depth records are lacking. It seems unlikely, however, that they came from the upper levels of the midden, for Dr. Jenness's own excavations there revealed only modern and late prehistoric types (Jenness, 1928, pp. 75-76). Moreover, none of these later types of harpoon heads or of the many other artifacts of similar age dug up by the Eskimos that I have examined are patinated to the extent of the specimens here described.

The harpoon head from the Hillside site, St. Lawrence Island, is shown in Fig. 6. Fig. 5 illustrates another head of the same type that the writer purchased from an Eskimo on St. Lawrence Island. Though its exact provenience is unknown it may have come from Okvik, the old Punuk Island site, as it is identical with those that Geist collected there.

Material.--All the specimens here described are of walrus ivory except that shown in Fig. 4, which is of bone. The original white of the ivory has been altered to various shades of yellowish brown (Figs. 1, 5), deep chocolate-brown (Figs. 4, 6), or gray (Fig. 3).

Shape. —Though possessing structural features that bring them into relationship with Old Bering Sea heads in general, these old Diomede and St. Lawrence examples do not exhibit the smooth finish and careful workmanship characteristic of other types of that period. They are crude and heavy in appearance and thick in cross section, with the two wider surfaces relatively flat. In contrast, other Old Bering Sea and later types are more graceful in outline, usually thinner in cross section, or, if relatively thick, have more rounded contours. The

side opposite the basal spur, instead of being beveled to an edge as usual, is flat and 1 to 1.3 cms wide. Only the upper edge, near the tip, is beveled.

Socket.—One of the features that distinguishes these harpoon heads from later types is the form of the open socket in which the upper end of the foreshaft rested. The socket is very wide and relatively shallow, and the walls have a slight outward flare, partly as a consequence of the floor being somewhat concave instead of flat. Also unusual are the deep parallel striations on the socket floor left by the cutting tool. These are clearly visible on all the specimens, though the drawing (Fig. 4, right) does not show them.

Beginning with this earliest known form, the open socket underwent a series of changes in prehistoric and protohistoric times (Collins, 1937, pp. 114, 210, 213–214). The Old Bering Sea heads exhibit the same general type of socket—wide and shallow with concave floor and slightly flaring walls—though in somewhat less extreme form. The oldest harpoon heads from Cook Inlet also have unusually wide sockets, which, however, are rounded rather than squared off at the upper end (de Laguna, 1934, pl. 38). In the succeeding prehistoric stages (Birnirk, Punuk, Thule) the socket becomes much narrower and deeper, with vertical sides and, on St. Lawrence Island, a flat floor. In protohistoric times the socket became triangular in cross section, the walls slanting inward to such an extent that the foreshaft remained in place without the aid of a lashing.

In one of the Diomede heads (Fig. 4) a narrow ivory wedge was inserted in the upper end of the socket to prevent the foreshaft from breaking through to the line hole.

Lashing slot and groove.—The foreshaft was held in place by a lashing, which passed through a narrow slot with a connected groove. The latter is deeper, narrower, and more carelessly made than most lashing grooves. This lashing arrangement of a single slot and an opposite groove is characteristic of some of the Birnirk and protohistoric types. It is rarely found on Old Bering Sea heads, which usually have two lashing slots.

A characteristic feature of the old Diomede and St. Lawrence heads is the sunken area just below the line hole on the side opposite the socket (see especially Figs. 2 and 5). The lashing groove crosses this sunken area and joins the slot, which thus emerges from under a projecting ledge. The ledge, continuing downward and curving inward, becomes part of the basal spur. An inward projection of the upper part of the spur is a feature often seen on Old Bering Sea heads, both

Figs 1–7 —Prehistoric harpoon heads 1–4, Little Diomede Island, Bering Strait; 5, St Lawrence Island; 6, St Lawrence Island (Hillside site, Gambell); 7, Punuk Island. Two-thirds natural size

of the open and closed socket types (Collins, 1937, pl. 23, figs. 4, 5, 12; pl. 24, figs. 12, 13, 15, 16; pl. 27, figs. 5–7).

Spur.—As in the case of most other Old Bering Sea heads, the basal spur is irregular. The most elaborate form is that shown in Figs. 4 and 5, with five and four separate prongs respectively. This is the form of spur that is found on the comparable harpoon heads from Okvik and Ipiutak. The other Diomede specimens (Figs. 1–3) lack definite prongs, the irregularity being effected by beveling. In Figs. 1 and 2 the spur is wedge-shaped at the tip.

Line hole.—With the exception of the example shown in Fig. 4 the line holes are somewhat larger than usual, averaging about 8 mm in diameter. One of the St. Lawrence heads (Fig. 5) differs from the others in having the line hole square and cut out rather than drilled. In the other examples the line holes are circular, having been made with a hand drill. In all cases the edges of the hole are beveled. A characteristic feature is a crude decoration of deeply incised lines forming a triangular area just above the line hole. Sometimes, as in Figs. 1–3, this roughened triangular area is sunken.

Upper end.—The terminal blade slit is sometimes in the plane of the line hole (Figs. 1, 4, 5), sometimes at right angles to it (Figs. 2, 6). In Fig. 3, as so often on Old Bering Sea heads, there are two deep slots for side blades just below the tip (not visible in the illustration); there was no end blade. The specimen illustrated in Fig. 1 is unique in that it had both side blades and an end blade.

Decoration.—The incised designs, though meager and crude, are not without significance. The arrangement of three pairs of radiating or converging lines above the line hole and on the upper part of the spur of Fig. 5, while very simple as a decorative device, is one of the commonest motives of Old Bering Sea style 1 from St. Lawrence, Punuk, and Diomede Islands (Collins, 1937, fig. 6 (10), p. 47; fig. 8, p. 53; pl. 13, fig. 7; pl. 14, fig. 5. Collins, 1940, pl. 14, A, fig. 8. Rainey, 1937, p. 604, harpoon head at upper right. Rainey, 1941, p. 154, harpoon head at right). Still simpler but equally diagnostic of Old Bering Sea style 1 are the pairs of short detached lines seen on the spur of one of the Diomede heads (Fig. 3) and above the line hole on another (Fig. 4. For other examples see Rainey, 1937, p. 604, and Collins, 1937, fig. 6 (1), p. 47; pl. 12, fig. 8; pl. 14, fig. 5). Other designs are deeply incised lines (Fig. 6), small T-shaped figures (Fig. 3), and lines with spurs attached (Fig. 2).

In Fig. 4 the decoration consists of an ordered arrangement of deeply incised lines either detached or attached as spurs to bordering

lines. Viewed from the sides to right and left of the socket (Fig. 4, center) the lines appear to radiate from a center, producing an effect similar to that of the converging lines referred to above. These lines, together with others just below them, combine to form a design suggestive of a human face. The ornamentation as a whole, with its deeply incised short lines and oblique spurs and its schematic representation of a human face, somewhat resembles prehistoric Dorset art from the Hudson Bay area (Jenness, 1925, fig. 9, Mathiassen, 1927, pl. 62).

The harpoon head shown in Fig. 7 is structurally unrelated to the type described above or to any other thus far known. It was excavated by the writer from the base of the 16-foot midden on Punuk Island. The depth at which it lay, its unusual form and ornamentation, and its deep patination are all suggestive of considerable age, even though we can not definitely assign it to any known period.

The material is walrus ivory. Like the Diomede specimen illustrated in Fig. 3, it is gray, a color rarely seen on old ivory.

The lower end is beveled at a 45° angle, and into this sloping surface the foreshaft socket was cut. The socket is enclosed and, unlike any other thus far known, is triangular in shape. It is very shallow, with a depth of only 1 cm at the lower, wider end and 3 mm at the upper. The line hole is oval and is placed laterally because of the presence of a prominent median ridge on both sides. On the socket side the tip was cut down to provide a bed for an end blade. On the opposite side is a deep narrow groove for the lashing that held the blade in place. This form of blade attachment is found on harpoon heads from Southampton Island in Hudson Bay but not elsewhere in the Eskimo area (Boas, 1901, fig. 87; Mathiassen, 1927, pl. 74, fig. 1). On either edge just below the line groove is a shallow depression, possibly a residual slot for a side blade.

Ornamentation consists of a random arrangement of straight lines, lines with spurs attached, and crosses. Both sides are decorated, but the surface is so worn that the designs on the socket side are barely visible. The decoration as a whole bears little resemblance to Eskimo art, though the spurred line is a characteristic Eskimo element. In its lack of an organized design it resembles some of the cruder examples of Old Bering Sea style 1. The writer has pointed out that the rather simple and diffuse ornamentation of style 1, with its emphasis on short detached lines and spurred lines, bears a closer resemblance to Paleolithic and Mesolithic geometric art, which was equally simple and variable, than to later styles in either America or Eurasia (Collins,

1937, pp. 294–296; 1940, pp. 585–586). In the case of the harpoon head shown in Fig. 7, the resemblance is even closer, both with respect to the individual elements and their arrangement. Whatever this may mean—and too much weight should not be attached to a single specimen—it is almost certainly pre-Old Bering Sea and in all probability one of the oldest Eskimo harpoon heads known.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

305TH MEETING OF THE ACADEMY

The 305th meeting of the Academy was held in the Assembly Hall of the Cosmos Club at 8:15 P M. on Thursday, April 17, 1941, with President A. H. CLARK presiding. The program consisted of a series of illustrated reports on various phases of the 1940 South American Eclipse Expedition sponsored by the National Geographic Society and the National Bureau of Standards, as follows:

The 1940 National Geographic Society–National Bureau of Standards Eclipse Expedition, by IRVINE C GARDNER, National Bureau of Standards.

The 1940 flash spectrum, by CARL C KIESS, National Bureau of Standards.

Sky brightness at Patos, Brazil, 1940, by EDWARD O. HULBURT, U. S. Naval Research Laboratory.

Ionosphere observations at the 1940 eclipse, by THEODORE R. GILLILAND, National Bureau of Standards.

Because of his unexpected absence, the scheduled contribution on A photographic determination of the time of contact during a total solar eclipse, by PAUL A. McNALLY, S. J., Georgetown University, was not given. Following the regular program, Dr. GARDNER presented some colored motion pictures of South American life and scenery

There were about 75 persons present. The meeting adjourned at 10:00 P.M. for a social hour.

FREDERICK D. ROSSINI, Secretary.

PHYSICAL CHEMISTRY.—*Physical reflections in a chemical mirror*.[1] R. E. Gibson, Geophysical Laboratory, Carnegie Institution of Washington.

Since it is a long-established custom in this Society that the retiring president give an address on some branch of natural philosophy with which he is acquainted at first hand or to which he has actually made contributions, I shall speak tonight about the physical chemistry of solutions. Superficially, a solution is the simplest result we know of the interaction of unlike species of matter and may be defined as follows. When two or more different substances are mixed, we frequently find that a mass is produced that is homogeneous to all macroscopic criteria, whose properties are somewhere intermediate between those of the original components, and from which these components may be recovered by relatively simple operations. Such a mass is called a solution: physically, it acts as a single phase of matter; chemically, its composition is continuously variable within wide limits, a fact that distinguishes it from the orthodox chemical compound.

Although solutions may be solids, liquids, or gases, liquid solutions have claimed most of our attention because of the fact that matter occurs in a relatively dense, readily confinable, but highly mobile form in liquids. Their external mobility, which permits their easy transfer from place to place, and their internal mobility, which makes them highly convenient media for chemical reactions, have given liquids a unique place in the dynamic phases of matter and life.

The main problems connected with a study of solutions seem rather simple and may be stated in the form of the following questions: (1) How can we predict exactly the properties and behavior of a solution from a knowledge of those of its components? (2) What characteristics of a solid and a liquid cause the former to dissolve in the latter? How is solubility influenced by pressure, temperature, and other dis-

solved substances? (3) What types of interaction take place among the molecules of different species intimately mixed in a solution; what deductions about these interactions can we make from observations on solutions and conversely; how do these interactions foreshadow profounder changes that may occur subsequently in the solutions?

Answers to these questions, which really represent particular phases of the general problem of molecular interaction, might enable us to understand the processes going on in the vast solutions that lie *around* us in the oceans, *below* us, transporting materials within the earth, and *within* us, giving us nourishment and forming an essential link in that complex chain of processes we call life. Through the medium of solutions in water, the soul of man finds expression in the creation of beauty or the search for truth, and only through the same media can he appreciate these achievements. There is no doubt of our conscious or unconscious familiarity with solutions. From a more objective point you are well acquainted with solution phenomena; you have all seen salt or sugar dissolve in water; some of you may have studied more complex solutions such as those of alcohol, sugar, and water; you may have been struck by the mystery of a rigid, massive solid being reduced to a state of mobility by mere contact with a liquid; you may have wondered what happened to the solid. So have many hundreds of generations of men before you. Each generation has contributed to our knowledge of the phenomena of solutions, has added some new facts, and each generation has tried to explain these facts. Unfortunately, each generation has been better at discovery than at explanation—has raised more problems than it has solved—and each generation has outgrown the simpler explanations it inherited. The study of solutions has now grown to be very complex; an exact description of the large body of facts that has been accumulated about the properties of solutions in terms of a few simple postulates, in short, a theory of solutions, suffers from the same evil that besets all generalizations about phenomena close to our everyday lives. We know too much about the facts to be satisfied with theories based on simple abstractions and too little to trace the guiding clues through their manifold complexities or to handle simultaneously the many variables that must be considered. From the point of view of a lecturer to a general audience, therefore, the subject I wish to discuss tonight is in a very unsatisfactory state. My problem has been to distill from the mass of material available some thoughts on the subject that might be condensed into the space of one lecture and still be of interest to you.

THE HISTORICAL APPROACH TO COMPLICATED PROBLEMS

In the first verse of the fifty-first chapter of the Book of Isaiah, you will find the words "Hearken to me, ye that follow after righteousness, ye that seek the Lord: look unto the rock *whence* ye are hewn, and to the hole of the pit *whence* ye are digged." I have always been fascinated by this passage in which Isaiah exhorts us to make or renew the acquaintance of our intellectual ancestry, to seek an understanding of things as they are from a deeper knowledge of how they came to be so, and I think that we may apply this thought with profit to such a complex problem as the theory of solutions.

I wish, however, to digress a moment and call your attention to some thoughts of a general nature that are suggested by Isaiah's exhortation. It is quite certain that even in their wildest dreams neither the prophet nor his hearers ever imagined that men could spend their lives in the pursuit of what we call Science, and yet his words and the very figures of speech employed are so happy in their application to natural philosophers that I would advocate their inscription on the walls of all places where scientific research is fostered. Consider the phrase "look to the rock whence ye are hewn." Does it not imply a high degree of permanence in the system of which we are a part? Does it not imply an association in something much more fundamental and lasting than ourselves? It is interesting to compare this thought with that expressed by Wordsworth and familiar to all readers of "Nature":

> To the solid ground
> Of Nature trusts the mind that builds for aye.

We have assurance that this is not just poetic fancy from the researches of one of the greatest scholars in the history of science, for George Sarton has stated as his considered opinion that "scientific activity is the only human activity that is obviously and undoubtedly cumulative and progressive."[1] To continue the metaphor, each chip hewn from the rock is a step toward the final statue. We see the image more clearly and hew our chips more intelligently because of the work done by our ancestors. In other words, scientific progress is the one thing we can bequeath to posterity that will not be nibbled at by inheritance taxes on personal reputations, annihilated by the inflations or deflations of fluctuating fashions and taste, or squandered by carelessness or indifference.

Dignified as the metaphor of the rock may be, the exhortation to "look to the pit whence ye are digged" is even more appealing to

[1] SARTON, G. *The history of science and the new humanism*, p 24. New York, 1931.

chemists and biologists and others who work in the messier regions of science. The metaphor implies a humble origin, an intimate contact with the soil of life, a certain amount of monotonous drudgery, a painful groping and digging in an a most boundless quarry for something we do not even know to be there, a laborious sifting of the gold from the dross. It also carries a warning that even when the nugget of truth is found, it will be contaminated with the dirt of irrelevancy or error.

The broadened outlook on scientific problems that comes to many of us most easily through a background of historical knowledge, through looking into "the pit whence we are digged," is so valuable that I think at least one member of each of the scientific departments of our large graduate schools should be versed in this aspect of his subject. I do not advocate that the memories of graduate students already burdened with a heavy technical load should be made to carry an extra weight of names and dates, but that there should be someone to stimulate them to ask: Where did this idea come from, how did this theory arise? Habits of thought so stimulated can make several significant contributions to the intellectual equipment of research workers. In the first place, even a moderate familiarity with the historical development of our own or cognate fields enables us to put ourselves into the frame of mind of the masters who made the great advances in the past. If we take the trouble to understand their background, the problems as they saw them, the ideas available to them and the sources of these ideas, we can trace their steps through the arguments leading to important conclusions and try to emulate them. Glimpses of the turning points where they hesitated and the reasons that led them to prefer one road to the others are probably more valuable to the research student than the great discoveries themselves that now form an integral part of recorded science.

Secondly, I think we can gain the confidence that comes from a perspective of our subject, a perspective that enables us to differentiate between apparent difficulties that arise from elaboration of simple principles and real difficulties that arise from lack of principles or absence of a trustworthy logic for handling simultaneously the numerous variables of a complicated problem. An interesting result of even a superficial study of this sort is the realization that the intrinsically mysterious parts of physics, chemistry, or biology are not the theories but the phenomena presented by nature and observed by experiment. What the mind of one man can invent, that of another can grasp, granted that the proper effort is made and that the theory is not purely fantastic; but we must still agree with Hamlet that "there

Ralph E. Gibson, retiring president of the Philosophical Society of Washington

are more things in heaven and earth than are dreamed of in our philosophy." The basic ideas, the concepts, and the hypotheses on which the theories of physics and chemistry are based were drawn originally from every-day experience and are very limited in number; for example, pushing with a stick (waves) and throwing stones (particles) are the only mechanisms we can imagine for action at a distance. As a science develops, the concepts and hypotheses are refined and modified in the light of the new specialized experience, with the result that the very foundations of a theory become somewhat removed from every-day experience, and the beginner is confronted with difficulties that are not lessened by the limitations of our vocabulary. An excursion into the past leading to a knowledge of where these ideas came from and how they grew helps greatly in removing these obstacles.

An unnecessary source of difficulty in the theoretical phases of science is the natural and, in some ways, laudable passion for elegance on the part of some thinkers. In constructing their theories these men start from current ideas, explore and reject many possibilities, and frequently achieve success by an inspired guess which is justified *a posteriori* by rigorous means. When their theory is finished, they proceed to polish it, to obliterate the traces of fumbling, to revise and refine the basic ideas and, in short, they end by presenting a picture that is most satisfying to one who is already familiar with the result but that is baffling to the unsophisticated. The nugget of truth is so carefully polished that all traces of the pit are removed. One can not condemn this desire, but one can deplore the loss of those revealing intermediate steps that might have meant so much to the neophyte. I am convinced that the difficulty that most chemists and many physicists encounter in learning mathematics arises from this source. The subject has been worked over by many generations of mathematicians who have not only polished out the marks of the chisel but have also surrounded the rock with the cloud of generality and covered it with the moss of rigor.

In the light of a historical survey, we may also see that many of the controversies between seemingly rival theories arose largely from the fact that the antagonists, working on different aspects of the same complex problem, derived their basic ideas from different backgrounds of experience. I shall illustrate this later by the so-called physical and chemical theories of solutions. Human limitations have forced us to split up the study of nature into different fields. While organizers, administrators, and others who can not function without labels have

made the most of this classification, it is one which the true natural philosopher will never cease to fight. The history of science is full of examples of great advances that came from the transfer of ideas from one field to another: Kekulé advanced organic chemistry because he had been an architect; Faraday made some of his greatest contributions to physics because he was also a chemist. Frequently a satisfactory theory of complex phenomena can be developed only when concepts and hypotheses from several of the arbitrary divisions of science are combined.

ORIGIN AND DEVELOPMENT OF SOME IDEAS USED IN THE THEORY OF SOLUTIONS

In asking you now to accompany me in taking a few fleeting glances into the pit whence our modern theories of solutions have been digged, I want first to indicate one general conclusion for your guidance. We shall see that the subject is not so narrow as might appear at first sight, because, in their attempts to understand the highly complex problems presented by solutions, investigators have pressed into their service all the physical and chemical ideas available to them in their age. Consequently, the story of the development of the theory of solutions is a mirror in which we see reflected the advances in physical and chemical thought of all the ages, and I have borrowed this figure of speech with modifications from P. Walden[3] to serve as the title of this address.

Early Physical Theories

Somewhat arbitrarily, I shall begin this story in the first half of the seventeenth century A.D., not because the speculations made prior to that time lacked interest—in some ways they are the most interesting part of the subject—but because this period marks the beginning of a radical departure from the use of purely anthropomorphic ideas to the introduction of ideas culled from analyzed experience by students of the infant science of physics and the embryo science of chemistry. Up to this time the phenomena of solubility, especially of solids, had been explained in terms of the Doctrine of Affinity or the attraction of closely related materials. A liquid dissolved a solid because something in the solid was closely related to the liquid and wanted to be with it. The introduction of new ideas may be illustrated by a quotation from Robert Boyle[4] written in 1663 which sums up one advanced school of thought at that period:

[3] WALDEN, P.   *Die Lösungstheorien in ihrer geschichtlichen Aufeinanderfolge*, p. 3. Stuttgart, 1910.
[4] BOYLE, R.   Essay entitled "Of the Producibleness of Chymical Principles" (1663). See *The Works of Robert Boyle*, London, 1772.

These two objections I thought fit to couch together, to be able, in fewer words, to answer them both: I considered then, that amalgamation being, in effect, but a kind of dissolution of metals in a menstrum or fluid body (for such mercury is, in reference to them), there is no necessity, that the solvent should find in the metal a copious ingredient just of its own nature; for dissolution depends not so much upon the pretended cognation between the solvent and the body it is to work on, as upon congruity, as to size and figure, between the pores of the latter and the corpuscles of the former

Sixteen years earlier, Pierre Gassendi[5] (1592–1655) had given a similar atomistic theory of solutions. He held that all matter was made up of atoms or molecules that had characteristic sizes, shapes, and weights. When these atoms were packed together to give a solid or liquid, small interstices or pores remained, and when a salt dissolved in water it merely occupied the pores in the water, the solution becoming saturated when all the pores were filled. The shapes of the corpuscles of matter were inferred from their crystalline forms; thus common salt had cubic corpuscles, and this argued the presence of cubic pores in water; alum had octahedral corpuscles, and it was concluded that there were octahedral pores in the water. Lack of solubility indicated the absence of pores of the proper shape.

The French philosopher N. Lemery[6] also developed ideas of the same type. By the middle of the seventeenth century, therefore, physicists were using ideas about the nature of solutions that are current today, the corpuscular nature of matter and the geometrical ideas of packing. The atomic nature of matter was firmly embedded in their thinking, a fact that is not surprising in view of the material available. In their speculations about matter they had two, and only two, alternatives based on analogy with every-day experience to choose from. Either matter resembled a liquid, such as water, and was continuous, i.e., divisible without any limit, or it resembled a heap of unbreakable stones, i.e., was atomic in nature. Those philosophers who studied the phenomena of solutions could not bring themselves to believe that two continuous bodies, such as salt and water, could intermingle with such ease, and for this and other cogent reasons they had to reject the continuous theory of matter and adopt the only other possible choice. With the rock-pile hypothesis, the interstices or pores must, of course, go, and the step from this to geometrical relationships and the packing together of bodies is a short one. The hypothesis of pores or voids in liquids was strengthened somewhat later by the observations of Bishop Watson[7] and of Reaumur[8] that a contraction occurred when

[5] GASSENDI, PIERRE. *Opera Florentiae*, 1684 See MELLOR, J W. *A Comprehensive treatise on inorganic and theoretical chemistry*, vol 1, p 574, London, 1922.
[6] LEMERY, N *Cours de chymie*, Leyden, 1716 See WALDEN, op cit, p. 25.
[7] WATSON, R   Phil Trans 59: 325, 354   1770
[8] REAUMUR   See WALDEN, op cit., p 28

many pairs of liquids were mixed. These we might call the physical or mechanical theories of the Age of Boyle.

Early Chemical Theories

There were other notable investigators who even in the eighteenth century rejected this purely mechanical picture of the phenomenon of solution and held that solution represented a union between the solvent and the solute (F. Hoffmann, 1722), or implied a definite relationship (affinity) and similarity between the solvent and the dissolved substance (Stahl). Still another worker (Digby, 1603–1665) suggested that when a salt dissolves in water, each particle of salt incorporates with itself at least one particle of water, an intimate union suggestive of the hydrate theories that are still used.

These were chemical theories of the Age of Boyle and are mentioned here chiefly to introduce the rivalry between the so-called chemical and mechanical or physical theories of solutions that has persisted almost to this day.

Physical Theories of the Eighteenth Century—Influence of Newton

At the beginning of the eighteenth century, new ideas were introduced into the theory of solutions that reflected the tremendous advances in physics that marked the preceding 25 years. Newton's studies in optics, particularly of the phenomena of refraction and double refraction, led him to speculate on the nature of the interaction of light and matter and, incidentally, the nature of matter in general and of solutions in particular. I quote the following passages from Part I, Book 3, of Newton's *Opticks*, published in 1704.[9]

Quest 31. Have not the small Particles of Bodies certain Powers, Virtues or Forces, by which they act at a distance, not only upon the Rays of Light for reflecting, refracting, and inflecting them, but also upon one another for producing a great Part of the Phænomena of Nature? For it's well known, that Bodies act one upon another by the Attractions of Gravity, Magnetism, and Electricity; and these instances shew the Tenor and Course of Nature, and make it not improbable but that there may be more attractive Powers than these. For Nature is very consonant and conformable to herself. How these Attractions may be perform'd, I do not here consider. What I call Attraction may be perform'd by impulse, or by some other means unknown to me   I use that Word here to signify only in general any Force by which Bodies tend towards one another, whatsoever be the Cause. For we must learn from the Phænomena of Nature what Bodies attract one another, and what are the Laws and Properties of the Attraction, before we enquire the Cause by which the Attraction is perform'd. The Attractions of Gravity, Magnetism, and Electricity, reach to very sensible distances, and so have been observed by vulgar Eyes, and there may be others which reach to so small distances as hitherto escape Observation; and perhaps electrical Attraction may reach to such small distances, even without being excited by Friction

[9] NEWTON, ISAAC.   *Opticks*. Reprinted from ed. 4 (William Innys, London, 1730), pp 375, 387. G Bell and Sons, Ltd , London, 1931

For when Salt of Tartar runs *per Deliquium*, is not this done by an Attraction between the Particles of the Salt of Tartar, and the Particles of the Water which float in the Air in the form of Vapours? And why does not common Salt, or Salt-petre, or Vitriol, run *per Deliquium*, but for want of such an Attraction? Or why does not Salt of Tartar draw more Water out of the Air than in a certain Proportion to its quantity, but for want of an attractive Force after it is satiated with Water? And whence is it but from this attractive Power that Water which alone distils with a gentle luke-warm Heat, will not distil from Salt of Tartar without a great Heat? And is it not from the like attractive Power between the Particles of Oil of Vitriol and the Particles of Water, that Oil of Vitriol draws to it a good quantity of Water out of the Air, and after it is satiated draws no more, and in Distillation lets go the Water very difficultly? And when Water and Oil of Vitriol poured successively into the same Vessel grow very hot in the mixing, does not this Heat argue a great Motion in the Parts of the Liquors? And does not this Motion argue, that the Parts of the two Liquors in mixing coalesce with Violence, and by consequence rush towards one another with an accelerated Motion? . .

If a very small quantity of any Salt or Vitriol be dissolved in a great quantity of Water, the Particles of the Salt or Vitriol will not sink to the bottom, though they be heavier in Specie than the Water, but will evenly diffuse themselves into all the water, so as to make it as saline at the top as at the bottom And does not this imply that the Parts of the Salt or Vitriol recede from one another, and endeavour to expand themselves, and get as far asunder as the quantity of Water in which they float, will allow? And does not this Endeavour imply that they have a repulsive Force by which they attract the Water more strongly than they do one another? For as all things ascend in Water which are less attracted than Water, by the gravitating Power of the Earth; so all the Particles of Salt which float in Water, and are less attracted than Water by any one Particle of Salt, must recede from that Particle, and give way to the more attracted Water

When any saline Liquor is evaporated to a Cuticle and let cool, the Salt concretes in regular Figures; which argues, that the Particles of the Salt before they concreted, floated in the Liquor at equal distances in rank and file, and by consequence that they acted upon one another by some Power which at equal distances is equal, at unequal distances unequal For by such a Power they will range themselves uniformly, and without it they will float irregularly, and come together as irregularly. And since the Particles of Island-Crystal act all the same way upon the Rays of Light for causing the unusual Refraction, may it not be supposed that in the Formation of this Crystal, the Particles not only ranged themselves in rank and file for concreting in regular Figures, but also by some kind of polar Virtue turned their homogeneal Sides the same way

The Parts of all homogeneal hard Bodies which fully touch one another, stick together very strongly And for explaining how this may be, some have invented hooked Atoms, which is begging the Question; and others tell us that Bodies are glued together by rest, that is, by an occult Quality, or rather by nothing; and others, that they stick together by conspiring Motions, that is, by relative rest amongst themselves. I had rather infer from their Cohesion, that their Particles attract one another by some Force, which in immediate Contact is exceeding strong, at small distances performs the chymical Operations above-mention'd, and reaches not far from the Particles with any sensible Effect.

These quotations show quite clearly, I think, that the Atomic Theory of matter was firmly fixed in Newton's mind and that he saw in chemical phenomena, including solutions, an application of the same ideas that he had used so successfully in describing the motion of

heavenly bodies. We see here the introduction of the idea of forces between atoms or molecules, forces which *varied with the distance* and not only compelled them to attract or repel each other but to influence light. This was really a great advance over the older ideas that chemical interaction resulted from the desire of like bodies to be together. We see also the evolution of a specific nature in these forces, together with ideas of saturation. It is also interesting to note that Newton had a clear picture of the relationship of heat to molecular motion and the use of thermal measurements for estimating the magnitude of the forces holding the corpuscles of matter together, although nearly 150 years were to elapse before the kinetic theory of heat became firmly established.

Although Newton is purposely and cautiously vague about the nature of the forces between atoms, he did extrapolate his gravitational theory far enough to say one thing about these forces and make thereby a most important advance over the current ideas. He does imply that these intercorpuscular forces are functions only of the distance between the particles, "by some Power which at equal distances is equal and at unequal distances unequal," and he shows that regularity in the spatial arrangement of the particles of solid bodies follows from such a law. He goes even farther, and from his observation on the double refraction of crystals of calcite he arrives at the idea of orientation of the ultimate particles of calcite that arise from a "polar virtue" of those molecules, i.e., a property whereby the forces acting on one part of the molecule are different from those acting on the other.

In some form or other, these ideas of Newton are in use today, and I have spoken of them in some detail, not for the purpose of showing that Newton foreshadowed many modern theories of solution but to show how a powerful mind took ideas from his analyzed experience in the study of the motions of heavenly bodies and the properties of light, extracted some of the *essentials* and applied them in an entirely different field with results that still excite our interest and admiration.

These ideas of Newton were slowly absorbed during the eighteenth century and were reiterated and developed by the French naturalist Buffon (1707–1785),[10] who wrote, "The laws of affinity are the same as the general law which governs the interaction of the heavenly bodies, the specific attractions (attractions particulières) are due solely to the shapes (figures) of the molecules because these shapes enter as an element in the distance between them." He goes on to show how the shapes of the bodies are unimportant in astronomy but may be very

[10] See Walden, *op. cit.*, p. 37.

significant in determining interactions in bodies as close together as molecules.

The end of the eighteenth century also saw a definite realization among philosophers that the phenomena of solubility, of the density of bodies, their adhesion, cohesion, and chemical affinity, all were related through a single unifying principle, the attractive forces between the units of matter. There were still, however, two main schools of thought, the *physical school* and the *chemical school*. The former based their theories on ideas such as those I have just outlined, the latter insisted that a solution represented a chemical combination between the solvent and the dissolved substance. This school (Wallerius, Klaproth, and others) held that the cohesion and adhesion of matter also was a chemical phenomenon and that solutions depended on the balance of the adhesive (unlike molecules) and cohesive (like molecules) affinities. It is evident that the difference between the physical and chemical theories depended mostly on the background of the thinker, whether he chose his fundamental ideas from physics, the attraction, shape, pores, or geometry of large bodies, or whether he chose his ideas from experience in the violent combinations known as chemical reactions.

An important clarification of thought concerning solutions was made by Lavoisier toward the end of the eighteenth century when he distinguished between solution and dissolution. Solution he reserved for reversible phenomena, such as the dissolving of salt in water, when the salt is recovered by simple evaporation. He applied the term dissolution to cases such as the dissolving of a metal in an acid where the metal is not recovered on evaporation, but instead of it a salt. In this case a definite chemical change accompanied the process of solution.

The Early Nineteenth Century—Chemical Theories

The beginning of the nineteenth century saw the introduction of the atomic theory of matter into experimental chemistry through the law of definite proportions, the law of multiple proportions, and the law of reciprocal proportions. From these empirical laws, the chemists Dalton, Richter, and Berzelius established a quantum theory of chemically reacting masses that sharpened the definition of a chemical compound and soon increased the embarrassment of those who held the view that solutions were purely manifestations of chemical combination. Some, however, like C. L. Berthollet, never accepted the laws of definite and multiple proportions and could therefore consistently retain such opinions. Others, in spite of an acceptance of

Dalton's theory, continued to believe that the dissolved substance and the solvent were chemically combined. An excellent summary of the chemical theory of solutions from 1800 to 1880 is given by W. A. Tilden,[11] who quotes a statement by Josiah P. Cooke written in this country in 1881 that "the facts seem to justify the opinion that solution is in every case a chemical combination of substances dissolved with the solvent, and that it differs from other examples of chemical change only in the weakness of the combining force."

Time does not permit me to elaborate further on these chemical theories; I have felt that some discussion of them is necessary in order to balance the picture, but we must return to the main subject and see how the advances in physics during the nineteenth century are reflected in the theories of solutions. We shall see later the ultimate fate of the controversy between chemical theories and physical theories.

Electrical Theories

By the year 1800 sources of voltaic electricity had been developed and the fundamental laws governing the attraction and repulsion of electrostatic charges had been established by the physicists. Chemical effects of electrical currents also were being investigated. It is not surprising, therefore, that electrical ideas were incorporated into chemical thought at this time. We are all familiar with the extensive theory in which Berzelius attempted to explain all chemical combination by the action of forces between electrical charges, an attempt that failed because chemists of that time knew too much about chemistry and the physicists too little about electricity. Some years before Berzelius's theory, Th. von Grotthuss applied electrical ideas to solutions, particularly those that conducted electricity. He considered water as a dipole, the hydrogen being associated with positive electricity and the oxygen with negative electricity, and assumed that a continuous dissociation and recombination of these dipoles took place so that there was a constant interchange of partners among the water dipoles. In the same way an electrolyte, such as a salt, was supposed to be composed of a positive and a negative part (e.g., Na^+ and Cl^-) and it was thought that a constant exchange of partners among the dissolved molecules also occurred. All this happened without the passage of electric current through the solution, but, as we should say today, the exchange of partners was purely random. When positive and negative electrodes were placed in the solution, a direction was given to this exchange with the result that current flowed and electrolysis took place.

[11] TILDEN, W. A.   British Assoc. Reports, 1886, p 444

Of especial interest is the picture that Grotthuss gave of the solubility of electrolytes, e.g., salts. He suggested that the solubility of such substances depended on their capacity to split up their "polarelectric elementary particles," i.e., ions, and in the association of these ions with the molecular galvanic activity of the water. The work of Grotthuss marks the introduction of ideas drawn from electrical observations to give a mechanism for the vague ideas of chemical affinity, and he suggests that the solubility of salts in water is an electrochemical phenomenon depending on the interaction between the water molecules acting as electrical units and the ions into which the dissolved electrolytes resolve themselves.

The Kinetic Theory

The next important set of ideas that we find introduced into the theory of solutions reflects an advance in physics for which the nineteenth century will always be famous in the annals of science. I refer to the establishment of the kinetic theory of heat and matter on a firm experimental and logical basis by Clausius and others.

Members of both the physical and chemical schools of thought in the early nineteenth century seem to have had a clear recognition of the relations between those forces that caused one substance to dissolve in another and those forces that gave rise to cohesion in solids and liquids. For example, the French chemist Dumas[12] wrote in 1836, "Molecular attraction manifests itself in three well differentiated ways, between molecules of one and the same body, this is the ordinary cohesion of the physicists, between more or less similar molecules, which mix in such a way as to preserve their individual properties— that is the force of solution, and finally between dissimilar molecules which unite intimately giving a product of quite different properties— this is Affinity." Such views were generally held and attempts were made to explain the solubility of solids and especially saturated solutions in terms of competing forces—forces between the solvent and solute molecules producing solution on the one hand and forces of cohesion opposing the dispersion of the solid on the other. These investigators apparently felt the need of a *general type of force or agency opposing cohesion*, an agency that tended to separate molecules from each other. Newton supplied this need by repulsive forces, but it is just as well that his ideas on this subject did not spread, although it is to be regretted that no one followed up his ideas of heat as a measure of molecular attraction.

[12] Dumas, J. B. A. *Leçons sur la philosophie chimique*, ed 1, p 391. Paris, 1837.

When the theory that heat is a form of molecular motion was firmly established on an experimental basis, this general dispersing agency was at once apparent in the kinetic energy of the molecules. For example, Clausius and Joule showed that the pressure of a gas was entirely due to the motion of the molecules, and the processes of melting, evaporation, and sublimation were at once thought of as taking place when the temperature and hence the kinetic energy of the molecules became large enough to overcome the forces of cohesion.

From 1860 to 1885, therefore, a number of theories, e.g., those of L. Dossios (1867), W. W. J. Nicol (1883), Gay-Lussac, and W. A. Tilden and W. A. Shenstone (1884) appeared in which the kinetic energy of the molecules played an important role in the discussion of solubility and other phenomena connected with solutions. For example, Tilden and Shenstone examined the connection between the solubility and the fusibility (melting point) of salts showing in general that the lower the melting point, the more soluble was the salt, and wrote:[18]

But the connexion between fusibility and solubility, though proved does not wholly explain the nature of the initial stage in the process of solution of a solid It does, however, strongly support a kinetic theory of solution based on the mechanical theory of heat The solution of a solid in a liquid would accordingly be analogous to the sublimation of such a solid into a gas, and proceeds from the admixture of molecules detached from the solid with those of the surrounding liquid Such a process is promoted by rise in temperature, partly because the molecules of the still solid substance make larger excursions from their normal centre, partly because they are subjected to more violent encounter with the moving molecules of the liquid Such a view does not necessarily involve the assumption of an "attraction" between the molecules of the solvent and those of the solvend (Cf L Dossius, Jahresb (1867), 92 Nicol, Phil Mag. Feb 1883)

Indeed it is difficult to disconnect "attraction"from the idea of combination resulting from such attraction In some cases we are considering, e g the solution of anhydrous Na$_2$SO$_4$ in water at 100°, nothing like combination between water and salt seems to occur.

We notice that the role of the attractive forces between molecules in solutions, introduced by Newton, is being abandoned and attempts are being made to explain all the phenomena by the kinetic theory.

The Kinetic Theory of Van't Hoff

These theories were, however, completely overshadowed by the kinetic theory picture developed a year or so later (1887) by van't Hoff from a study of the osmotic pressure of solutions. It had been known for a long time that, if a solution were placed in a strong vessel and connected with the pure solvent by a membrane permeable to the solvent, but not to the dissolved substance, solvent flowed through

[18] TILDEN, W. A , and SHENSTONE, W. A   Phil Trans Roy Soc 175A: 30   1884

the membrane into the solution until a definite pressure was developed in the vessel containing the solution. This pressure was called the Osmotic Pressure. Van't Hoff showed from the experimental results of Pfeffer that the following relationship held in dilute solutions: $\pi = (n/V)RT$ where π is the observed osmotic pressure, n is the number of gram molecules dissolved in a volume V, T is the absolute temperature, and the constant R has the same value as the well-known gas constant. The analogy of this result with the equation of state for an ideal gas $P = RT/V$ led van't Hoff to regard the dissolved substance as an ideal gas dispersed in a solvent whose role was that of a modified empty space and, of course, to treat the osmotic pressure as the pressure of an ideal gas, i.e., of purely kinetic origin. This theory was brilliant and led to some excellent experimental work, notably that of H. N. Morse and his students in Baltimore, who showed that the law was limited to very dilute solutions, if exact application were desired, and who studied the effects of temperature and the nature of the solvents and dissolved substances. The theory suffered from the fate common to all simple theories in this field, it long outlived its usefulness. You will notice that the theory exalts one idea, namely, the kinetic energy of the dissolved substance, to a position that excludes all the other considerations we have spoken of. Such a defect is fatal in so complicated a subject. The result was that several generations of chemists had to learn all about the osmotic pressure of solutions under the impression that it was a unique and fundamental quantity, and they tried to patch up the theory of van't Hoff to cover regions where, by its fundamental assumptions, it was inapplicable. Like too many theories, that of van't Hoff started as a strong current carrying the ship of science into broader waters of knowledge and ended up by being a whirlpool in which there was plenty of motion but all in a circle.

Thermodynamics—Entropy and Energy

The decade from 1880 to 1890 saw the beginning of a series of extensive and intensive researches on the properties of solutions which has continued unabated to this day. Indeed, these studies have constituted a major part of the science of physical chemistry that dates from 1887, the year of the publication of the first volume of the Zeitschrift fur Physikalische Chemie. In order to understand this activity, we must recall that by 1880 chemistry was on a sound basis. Not only was the atomic theory firmly established but definite and trustworthy ideas about molecules had also been developed and a consistent system of molecular and atomic weights was available. Hypotheses of

valency or the combining powers of the elements had been tested experimentally and a convenient, simple, and consistent scheme had been devised for the formulation of elements and compounds. At this time, too, we see a new reflection appearing in our mirror, a reflection that was to become a floodlight revealing relations among many apparently disconnected phenomena. I refer to the science of thermodynamics. Although thermodynamics and the kinetic theory were "nursed upon the selfsame hill," they are different in character. Classical thermodynamics is now a self-contained science based on two fundamental laws whose validity has been placed beyond doubt by experiment. From these two laws, deductions reaching into all branches of science have been made by unimpeachable mathematics. The science deals with experimental quantities, heat, work, temperature, pressure, and functions formally derived from them, and its theorems are exact. It is one of the few branches of physics that have come unscathed through the recent revolutions. The reason is that thermodynamic arguments depend only on observables and are independent of any hypothesis concerning the nature of matter.

The function of thermodynamics in physical chemistry has been to provide exact relations among observable quantities, thereby promoting economy, not only of measurement by limiting the number of experiments we have to do, but also of thought by allowing us to pass readily and exactly from measured quantities whose theoretical significance is obscure to those whose interpretation is more readily seen. In other words, thermodynamics gives us an exact system into which the experimental results of physical chemistry in general and the studies of solutions in particular, may be fitted, a system which enables us to examine the results from many points of view and pass to the more abstract quantities, such as energy and entropy, which lead directly into the kinetic theory and statistical mechanics.

Because of its very nature it was not to be expected that thermodynamics could supply any new mechanisms for use in the theory of solutions, but this science did make an important contribution to the theory in that imperceptibly but inexorably it forced physical chemists to think simultaneously of several variables, the forces between molecules, their geometry, and their kinetic energy. This came about because the thermodynamic criterion of equilibrium insists that we consider at the same time both energy and entropy, potential energy (forces), and kinetic energy (motion). I shall illustrate this by an example drawn from ideal solutions where changes of energy are zero.

Suppose I have two liquids A and B, such that the forces between

the molecules A and A, B and B, and A and B are the same, and I place A and B in contact. I shall find that at constant temperature, a spontaneous process takes place and that finally I get a homogeneous solution AB. If the liquids are properly chosen, careful measurements will also show that there is no heat and no volume change during the process, but in spite of this we know that the final state is definitely different from the initial state, and we want to find the physical quantity that reflects this change. Thermodynamics provides such a quantity in the *entropy* of the system and furthermore says that, since the change was a spontaneous one, the change in entropy is *greater* than the heat absorbed divided by the absolute temperature, i.e., greater than zero in this case. Hence the entropy *increased* during this process.

With the aid of the kinetic theory or elementary statistical mechanics, we can go farther and see that the entropy of a substance may be measured by the volume in configuration space that the coordinates of its molecules may occupy, together with the volume in momentum space that the points representing the momenta of its molecules and their moving parts may occupy. At constant temperature, we may consider that this latter part of the entropy is fixed and conclude that the increase of entropy that accompanied the mixing of liquids A and B arose solely from the fact that the molecules of each found larger volumes available to them. Indeed, from elementary statistical mechanics, we may see that the following expressions represent what happened:[14]

$$S_A - S_A{}^0 = -R \ln X_A \tag{1}$$

$$S_B - S_B{}^0 = -R \ln X_B. \tag{2}$$

Let us carry the argument one step farther and change the temperature so that one of our pure liquids freezes—we shall then be dealing with the solubility of a solid in a liquid; naphthalene in contact with benzene is an actual example that approximates to the conditions I am describing When the solution is saturated, we have coexisting at equilibrium solid A (naphthalene) and a solution of A and B. Under such conditions, thermodynamics tells us that the pressure and the temperature must be the same in both phases and that the following relation must hold for the component that is present in both phases, the naphthalene in this example:

[14] In this example the symbols have the following meaning S_A is the partial molal entropy of substance A in the solution, $S_A{}^0$ is the molal entropy of pure liquid A, $S_A{}^S$ is the molal entropy of solid A, X_A is the mole fraction of A in the solution S_B, $S_B{}^0$, $S_B{}^S$ and X_B are the same quantities for component B. H_A, $H_A{}^0$, $H_A{}^S$ are the molal heat contents corresponding to these entropies (the heat content is the total energy +the pressure multiplied by the volume) R is the conventional gas constant per gram molecule. T is the absolute temperature.

$$H_A{}^s - TS_A{}^s = H_A - TS_A \tag{3}$$

i.e.,

$$H_A - H_A{}^s = T(S_A - S_A{}^s). \tag{4}$$

and, if there is no heat change when the liquids are mixed,

$$H_A{}^0 - H_A{}^s = T(S_A - S_A{}^s) \tag{5}$$

where $(H_A{}^0 - H_A{}^s)$ is the ordinary heat of melting of the solid A, which may change with temperature but this change depends only on substance A and not on the solution. With the help of equation (1), we may go farther and write

$$\frac{(H_A{}^0 - H_A{}^s)}{T} = (S_A{}^0 - S_A{}^s) - R\ln X_A. \tag{6}$$

This picture gives a direct connection between solubility and melting in the ideal case. At the melting temperature of A, i.e., $T = T_m$, we know that $(H_A{}^0 - H_A{}^s) = T_m(S_A{}^0 - S_A{}^s)$ or $X_A = 1$, i.e., pure liquid A is in equilibrium with solid A.

Since solids freeze spontaneously below their melting points, we see that $(H_A{}^0 - H_A{}^s)/T$ is greater than $(S_A{}^0 - S_A{}^s)$ if T is less than T_m, in which case the equation is balanced only if $R\ln X_A$ is negative or X_A is between 0 and 1, a positive fraction representing the solubility of solid A in liquid B.

This example shows (1) that the solubility of solid A is due to the increased entropy that A gets when its molecules are dispersed in B (indeed, the term $-R\ln X_A$ actually measures this entropy change) and (2) that this solubility will increase with temperature, a well-known experimental fact.

This is the thermodynamic description of the state of affairs in an ideal solution and is the basis of a general theory of solutions today. Wherein does this differ from the theory of van't Hoff or other kinetic theories; are we still regarding the dissolved substance as an ideal gas in an inert medium? The answer is interesting. So far as the entropy change on mixing is concerned, we are considering the dissolved substance as an ideal gas, but as regards energy changes we are assuming that a molecule of A is acted on by the same forces when immersed in liquid B as when it is surrounded by molecules of its own kind. It is certainly not a gas from this point of view. The interactions between molecules A and A, B and B, and A and B are, therefore, of great importance, and only in very rare cases is an ideal solution, as pictured above, realized experimentally. Generally speaking, the solubility of A in B will be greater than the ideal solubility given by a calculation analogous to that just described if the A−B attractive forces are

greater than the A − A or B − B forces, and less if the opposite conditions hold. One of the chief lines of attack on the problem of solutions today is directed toward finding out the nature of intermolecular forces between like and between unlike molecules and applying this knowledge through statistical mechanics to obtain an adequate quantitative description of the properties of solutions as observed in the laboratory.[15] It should be mentioned that the intermolecular forces and the geometry of the systems not only influence the energy but also add to the entropy terms that must be considered along with the ideal entropy of mixing. In recent years some instructive attempts to calculate the energy and the entropy of solutions have been made.[16]

The point we have now reached in our consideration of the evolution of the ideas used in the theories of solutions is well into the twentieth century. Let us pause to gather together some of the ideas of which I have spoken. The list is by no means exhaustive, but it contains most of the raw material of which modern theories are made: (1) *Corpuscular nature of matter* (older philosophers); (2) *geometry of corpuscles or molecules*—size, shape, packing, voids or holes in packing (Boyle, Gassendi); (3) *general forces* between molecules—attraction and repulsion (Newton, Buffon—developments of mechanics); forces that are functions of distance only; (4) *orientation of corpuscles*—light as means of investigating matter (Newton); (5) *chemical theories*—specific but unknown chemical forces as opposed to general physical forces causing attraction or cohesion of molecules; connection between forces producing cohesion and forces producing solution; (6) *electrical nature of forces* causing chemical combination, cohesion, and solution —electricity in molecular systems (Grotthuss, Berzelius); (7) *kinetic theory of matter*—heat as form of molecular motion; disordering effect of heat and temperature; gas picture of solutions; relation of solubility and melting; (8) *thermodynamics*—unification of experimental results; quantitative studies of equilibrium and direction of physicochemical changes; heat *and* entropy; (9) *statistical mechanics*.

[15] Although by far the greater portion of the effort devoted to the study of solutions has been directed toward the problem of solutions of electrolytes in water and developments of great importance have been made in this field, limitations of space prevent the discussion of theories of electrolytes here It has been realised for many years that strong electrolytes exist mostly as positively and negatively charged ions in water solutions, and since the potential fields around ions are well known, the application of elementary electrostatics and statistical mechanics has led to noteworthy advances in the understanding of the subject. Electrolytes form a case where an important part of the intermolecular action (forces between the ions) is known. A general formulation of solution theory into which the treatment of electrolytes or non-electrolytes may be fitted is given by J G KIRKWOOD (Chem Rev 19: 275 1936)

[16] BERNAL, J D, and FOWLER, R. H   Journ Chem Physics 1: 515   1933; ELEY, D D, and EVANS, M. G   Trans. Faraday Soc 34: 1093   1938; EVERETT, D. H., and COULSON, C. A.   Trans Faraday Soc 36: 633 1940

RECENT DEVELOPMENTS

The next part of my story concerns the further development and refinement of these ideas, but now a change takes place in our perspective. We have been seeing various advances in physics reflected in the mirror of the chemistry of solutions, but now our mirror becomes transparent and we look through the phenomena of chemistry into the realm of physics that underlies them and find that the interface that separated these sciences was not real but was placed there by the limitations of our own point of view. Those unknown attractive forces about which Newton speculated, the same unknown forces that caused the disputes between those who supported the chemical theories and those who supported the physical theories, are becoming known, and in the light of this knowledge the boundary between physics and chemistry is fading. The faint reflection that Grotthuss and Berzelius caught has grown to the magnitude of a sun, and to its light we owe our present knowledge.

Even an outline of how this change has come about would take several lectures, and it is a subject with which most of you are familiar, anyway. I shall, therefore, merely mention a few landmarks.

Through the experimental researches of Faraday and the work of the brilliant theoretical physicists of the second half of the nineteenth century, notably Maxwell, the sciences of electromagnetics and electrostatics rose to their full stature. The researches of J. J. Thomson and his school, together with the discovery of radioactivity, established on an experimental basis the corpuscular nature of electricity and the electrical nature of matter. The researches of the spectroscopists, together with the inspiration of Bohr and his followers, when added to these results, have led to the universal acceptance of the theory that the atoms of matter are complex systems composed of elementary electrical particles, electrons, protons, positrons, etc. Finally, the development of quantum mechanics removed the last obstacle that stood in the way of a general conclusion that in principle all forces of attraction and repulsion between atoms and molecules arise from the complex electrostatic interactions of the charges of which they are composed. Thus those forces producing chemical combination, physical cohesion, the solubility of one substance in another, and all the other metamorphoses observed in nature are believed to be the result of a complex system of positive and negative electrical charges seeking a configuration of lowest potential energy. Based on quantum mechanics we now have a statistical mechanics

that leads us from molecular theory to the properties of matter in the bulk with no alarming contradictions.

"Chemical" and "Physical" Forces

The practical solutions of the problems of the interaction between the electrical systems that constitute atoms or molecules are, in general, difficult, but an important simplification has arisen from the fact that, by suitable approximation, the stable configurations may be made to fall into certain classes identifiable with the types of combining forces or bonds that the chemists have postulated by induction from their experiments, together with types of forces well known in experimental physics. Thus, in one type of configuration, the force between two atoms acts as a plain electrostatic attraction between two oppositely charged particles. This is the ionic link met with in salts such as sodium chloride. In another type of stable arrangement, we have a complex state of affairs that corresponds to the sharing of electrons between two atoms as postulated by G. N. Lewis. This is the covalent link, the common binding in organic chemistry and the formation or breaking of such bonds is what chemists usually mean by a chemical reaction. These bonds are directed and an atom can have only so many of them. Thus arise the combining laws of Dalton and the stereochemistry of van't Hoff. Another stable arrangement which was not at all understood before the quantum theory is that which gives the cohesion of metals.

Furthermore, molecules (as well as atoms) are electrical systems, and mutual interactions between their constituent charges lead to forces that hold them together or push them apart. In this class belong the "van der Waals' forces" of the older physicists or the "residual valencies" of the chemists. From the researches of Debye, London, and others, a fair amount is known about these forces. They arise from a variety of causes in which the size, the shape and the polarizability of the molecules play an important part. These are the forces most commonly encountered in non-aqueous solutions. In the light of modern knowledge and experience, however, we now recognize that any or all of the types of force enumerated above may be met with in solutions. The present status of the controversy between the "physical" and "chemical" schools may be summed up, therefore, by the phrase, "both are partly right."

I must mention, however briefly, one other fertile source of ideas that are applicable in a study of solutions, viz, the structure of crystalline solids, for this leads us back to the geometrical ideas of Boyle. Von Laue's discovery of the diffraction of X-rays by crystals, the

simplified theory and inspired experiment by the Braggs, the mathematical studies of the homogeneous packing of bodies in space by Schönflies, Federoff, and Pope and Barlow, and the untiring efforts of many workers in the last 30 years have given us a knowledge of how the atoms, ions, or molecules are arranged in crystals.

Hand in hand with this information about the geometry of solids has come, through studies of lattice energies, definite knowledge concerning the forces of cohesion in solids and liquids. For example, it is known that sodium-chloride crystals are held together by nondirected electrostatic forces between the charged ions which act as units together with a slight contribution from van der Waals' forces. The packing is determined by the relative sizes of the sodium and chloride ions. In diamond, on the other hand, the units (atoms of carbon) are held together by covalent bonds—the same bonds as in CH_4—and the structure in which one carbon is surrounded by four others is determined by the *direction* of these bonds. The bonds are very strong, and this accounts for the hardness of diamond and for the fact that it will not dissolve in any solvent, while sodium chloride dissolves easily in solutions of high dielectric constant.

On the other hand, an analysis of the structure of paraffin wax shows that the hydrocarbon molecule is the unit of structure. Within the molecule the carbon and hydrogen atoms are held together by very strong covalent forces, which practically neutralize each other's fields, leaving only the relatively weak van der Waals' forces to hold the solid together. This solid is weak, melts easily—it is easily soluble in other hydrocarbons like gasoline. Studies of solids have sharpened our ideas of the nature of cohesive forces and, at the same time, shown that these may be what used to be called purely chemical, as in diamond, or purely physical, as in paraffin wax or almost anything in between.

These studies have also made physical chemists conscious of geometry, of the important role played by the shape and size of atoms, molecules, or ions in determining solid structure. Many solids that are referred to as compounds but whose composition puzzled chemists in the past are now known to owe their existence to geometrical reasons, to the possibilities of packing in regular structures, rather than to the action of specific chemical bonds. It is also well recognized that congruity in the size and shape of the component ions or molecules is a most important factor in determining whether two substances shall form solid solutions. The old ideas of Boyle and Gassendi are still with us.

The application of these ideas of geometrical packing and the effect of intermolecular forces on it are now being carried over to liquids and solutions, where the determination of the molecular distribution in space is one of the most interesting problems.

CONCLUSION

We have traced in broad outline the development of the different ideas used in the theory of solutions and have seen how some of these ideas were taken from every-day experience and gradually shorn of their irrelevancies and molded into shape for quantitative use. Above all, I have tried to point out how developments in one science, viz, physics, were used in the development of a subject belonging to the cognate science of chemistry. In our excursion into the pit we have seen the remains of many muddling efforts in the past, attempts to explain complicated phenomena in terms of one or two simple ideas; we have seen, however, that each of these attempts contained a nugget of truth that is still a treasured possession in our store.

As a result of this excursion, I hope that the familiar sight of a crystal of common salt dissolving in water or sugar dissolving in a cup of tea will conjure before your mind a panorama of particles, motions, and forces. I hope that you will see the microscopic electrical systems of different sorts that constitute the ions of the salt or the molecules of the water being impelled to mix with each other in as disorderly a fashion as possible under the drive of their thermal motion, fulfilling their destiny by increasing the entropy of the universe. I hope that you will imagine these microcosms arranging themselves in positions of lowest energy into configurations that may sometimes suggest that they are joined by directed chemical bonds, sometimes that they are held by non-directed physical forces of varying magnitude, sometimes joined by a bond that combines the qualities of both those just mentioned. In your picture I hope you will also add geometrical considerations, that you will think of the sizes and the shapes (including the electrical distributions) of the ions or molecules and that you will note the effect of geometry on the energy (the forces) and the entropy (the motion) of the system as a whole. Above all, I hope that you will realize that the phenomenon you are witnessing differs from others you may have studied in that you can not get an explanation that will satisfy you if you exalt any one of these considerations to the exclusion of the others. Therein lies the complication.

I have left you with a picture of complexity, but if you will look to the hole of the pit whence it was digged, you will not be dismayed

by it. In the past, mathematicians have forged out of human experience methods of mechanical and exact development of ideas; they are still doing so and we have every reason to believe that mathematical methods for handling complicated problems where abstraction is undesirable will be available in the future. Our glimpse into the past gives us every assurance that a better understanding of solutions will come as time goes by, but we must expect that understanding to be based on concepts that are still further removed from our every-day experience.

BOTANY.—*New United States grasses.* JASON R. SWALLEN, U. S. Bureau of Plant Industry.[1]

Of the eight new species herein described, five are from the collections of W. A. Silveus in Florida (*Andropogon rhizomatus, A. niveus, A. sericatus*), Texas (*Sporobolus silveanus*), and Arizona (*Sporobolus patens*). *Sporobolus pulvinatus* and *Muhlenbergia villosa* are described from material previously referred to *S. pyramidatus* (Lam.) Hitchc. and *M. thurberi* Rydb., respectively, and *Glyceria cookei* is based on a collection of William Bridge Cooke from the Mount Shasta region of California.

Glyceria cookei Swallen, sp. nov.   Fig. 1

Perennis; culmi 15–30 cm alti, graciles, foliosi, erecti basi decumbentes, glabri; vaginae internodiis multo longiores, inferiores breves superiores elongatae, carinatae, scaberulae, marginibus hyalinis; ligula 5–7 mm longa, hyalina; laminae 3–5 cm longae, 2–3 mm latae, abrupte acutae marginibus scabris; paniculae 6–12 cm longae, simplices; spiculae breviter pedicellatae appressae vel anguste adscendentes, 15–18 mm longae; gluma prima 1.8–2.2 mm longa, obtusa, obscure 1-nervis; gluma secunda 3–3.5 mm longa, obtusa; lemmata 4–4 5 mm longa, 7-nervia, scabra, dentata, marginibus hyalinis; palea lemmate paulo longior, sulcata, bifida carinis alatis; antherae 0.8 mm longae.

Perennial; culms 15–30 cm tall, slender, leafy, erect from a decumbent branching base, glabrous; sheaths much longer than the internodes, the lower ones short, the upper ones somewhat elongate, keeled, scaberulous, the margins thin and hyaline, ligule conspicuous, 5–7 mm long, thin and hyaline; blades 3–5 cm long, 2–3 mm wide, abruptly acute, the margins finely scabrous; panicle 6–12 cm long, erect, unbranched; spikelets short pedicellate on the main axis, appressed or narrowly ascending, 15–18 mm long; first glume 1 8–2.2 mm long, oblong, obtuse, obscurely 1-nerved; second glume 3–3 5 mm long, similar to the first; lemma 4–4.5 mm long, 7-nerved, the nerves prominent, scabrous between the nerves, obtuse, irregularly dentate, the tip and margins hyaline; palea as long as or a little longer than the lemma, sulcate, bifid, the keels narrowly winged; anthers 0.8 mm long.

Type in the herbarium of the U. S National Arboretum, no. 98480, collected in a wet place on alluvial gravel in the Box Canyon of the Sacramento
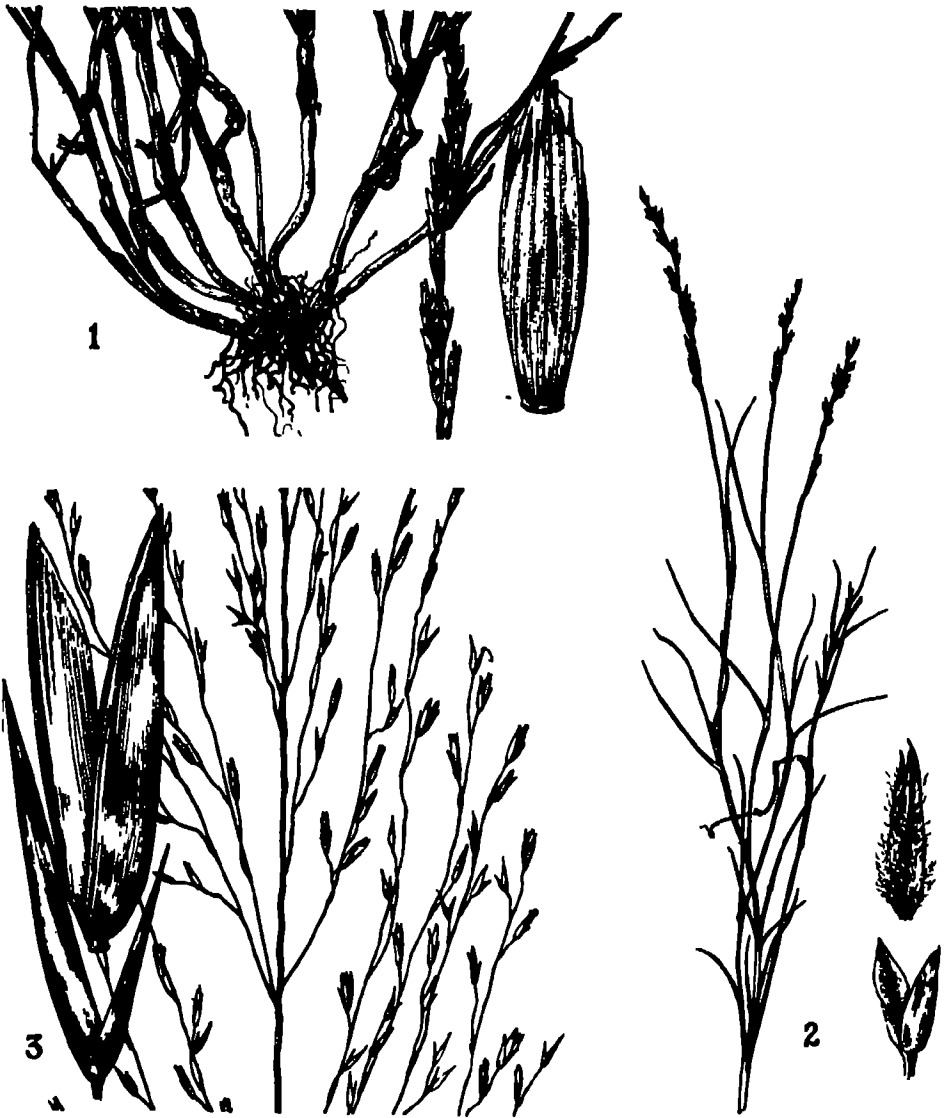
Figs 1–3.—New species of United States grasses, plants and panicles, ×1, spikelets, ×10· 1, *Glyceria cookei*, 2, *Muhlenbergia villosa*, 3, *Sporobolus silveanus*. Drawings from the type specimens by Mrs Frances C Weintraub

River near Mount Shasta City, Calif , altitude 3,000 feet, July 12, 1940, by William Bridge Cooke (no. 15312).

Glyceria cookei belongs to the section *Euglyceria*, in which the spikelets are linear and nearly terete. The known species of this group are all rather tall erect grasses with simple flaccid culms and relatively broad elongate blades. This species, however, has short, firm culms, decumbent and branching at the base, with short, narrow, spreading blades. It is evidently most nearly

related to *Glyceria occidentalis* (Piper) J. C. Nels. but differs in the above mentioned characters.

Muhlenbergia villosa Swallen, sp. nov.   Fig. 2

Perennis, rhizomatosa; culmi 10–20 cm alti, ramosi, puberuli, obscure nodulosi; vaginae internodiis breviores, glabrae; ligula 1–2 mm longa decurrens; laminae 2.5–3 5 cm longae, eae ramorum breviores, firmae, involutae, infra glabrae, supra pubescentes, marginibus scabris; paniculae 2–4 cm longae ramis brevibus appressis vel infimis divaricatis usque ad 1 cm longis; spiculae 2–2.5 mm longae breviter pedicellatae, appressae; glumae subaequales, 1–1.6 mm longae, acutae vel subobtusae, 1-nerves; lemma 2–2.5 mm longum, acutum vel mucronatum, marginibus infra medium villosis.

Perennial, culms 10–20 cm tall, wiry, rather freely branching, erect from scaly rhizomes, puberulent, obscurely nodulose roughened; sheaths mostly shorter than the internodes, glabrous; ligule 1–2 mm long, decurrent; blades 2.5–3 5 cm long or those of the shorter branches shorter, firm, involute, glabrous on the lower surface, pubescent on the upper, the margins scabrous; panicles 2–4 cm long, the short closely flowered branches appressed, or the lowermost sometimes stiffly spreading as much as 1 cm long; spikelets 2–2.5 mm long, short pedicellate, appressed; glumes subequal, 1–1.6 mm long, acute or subobtuse, 1-nerved, scabrous on the keel; lemma 2–2.5 mm long, acute or mucronate, the keel and margins villous on the lower half; palea villous on the keels.

Type in the U. S. National Herbarium, no. 1386596, collected 15 miles south of Stanton, Tex , July 11, 1928, by B. C Tharp (no. 5048).

This species is closely related to *M. villiflora* Hitchc. but is larger in all its parts The latter is rarely more than 10 cm tall with very wiry culms, arcuate spreading blades 0.5–1 cm long, narrow panicles 0.5–1.5 cm long, and spikelets 1 5–2 mm long. The differences are small, but the characters of *M villiflora* are very constant through a series of specimens from various localities.

Sporobolus silveanus Swallen, sp. nov.   Fig. 3

Perennis; culmi 85–115 cm alti, dense caespitosi, erecti, scabri; vaginae internodiis longiores, glabrae vel scaberulae in collo pubescentes, inferiores confertae, superiores elongatae; ligula 0 5 mm longa; laminae usque ad 45 cm longae, involutae, firmae, flexuosae, glabrae, marginibus scabris; paniculae 30–50 cm longae, ramis adscendentibus paucifloris, inferioribus 10–15 cm longis; spiculae 5–6 mm longae, purpureae, pedicellis 5–8 mm longis; gluma prima 3–4.5 mm longa, acuminata, secunda subacuta, lata, 4.5–6 mm longa, in carina scabra, lemma 5–6 mm longum, subacutum; palea lemma aequans, subacuta, obscure carinata; antherae 4 mm longae, nigro-purpureae.

Perennial; culms densely tufted, erect, 85–115 cm tall, scabrous at least toward the summit, leaves mostly crowded toward the base, those of the culm one or two with elongated sheaths; sheaths much longer than the internodes, glabrous or scaberulous, pubescent on the collar, the lower ones firm, straw-colored, shiny, the margins spreading and more or less papery with age; ligule erose-ciliate, 0 5 mm long; blades firm, flat or usually involute, glabrous on both surfaces with scabrous margins, those of the innovations elongate as much as 45 cm long, 1–2 mm wide, curved or flexuous, those of the culms much shorter, the uppermost 7–20 cm long; panicle narrow, mostly 30–50 cm long (or shorter on more slender culms) the branches ascending, rather distant, few-flowered, naked toward the base, the lower ones mostly 10–15 cm long; spikelets 5–6 mm long, purple, the pedicels 5–8 mm

long, appressed or somewhat spreading; glumes acuminate, scabrous on the keel, the first 3–4.5 mm long, 1-nerved, the second broader, 4 5–6 mm long, 3-nerved; lemma 5–6 mm long, subacute; palea about as long as the lemma, subacute, scabrous toward the tip, the keels obscure; anthers about 4 mm long, blackish purple.

Type in the herbarium of the U. S. National Arboretum, no. 98476, collected in open woods about 10 miles northeast of Orange, Tex., September 30, 1940, by W. A. Silveus (no. 6441)

This species is closely related to *Sporobolus floridanus* Chapm. and *S. teretifolius* Harper, the former differing in having flat blades as much as 5 mm wide, more densely flowered panicles, smaller spikelets 4–5 mm long with nearly equal glumes and the latter in having smaller panicles 15–25 cm long, pilose in the axils, and slightly smaller spikelets with a narrower first glume which is usually less than half as long as the second. The long sparsely flowered panicles of large purple spikelets are very striking and characteristic

Sporobolus pulvinatus Swallen, sp nov   Fig 4

Annuus; culmi 5–30 cm alti, caespitosi, basi decumbentes, glabri: vaginae internodus breviores, glabrae, in ore plusminusve hispidae; ligula ciliata, 0 5 mm longa, laminae 4–7 cm longae, 2–5 mm latae, utrinque scabrae, ea suprema multo reducta, paniculae 2–8 cm longae, pyramidatae, ramis verticillatis appressis vel divaricatis, basi nudis, densifloris; spiculae 1 5–1.7 mm longae, breviter pedicellatae, appressae; gluma prima minuta, gluma secunda et lemma aequalia, abrupte acuta vel subobtusa, palea lemma aequans, minute dentata; antherae 0 3 mm longae, pallidae

Annual; culms 5–30 cm tall in small or rather dense tufts, decumbent spreading at the base, glabrous, sheaths shorter than the internodes, glabrous, more or less hispid at the throat; ligule ciliate, about 0 5 mm long; blades mostly 4–7 cm long, 2–5 mm wide or smaller in depauperate plants, lanceolate-acuminate, scabrous on both surfaces and on the thick white margins, the uppermost much reduced; panicles 2–5 cm or rarely as much as 8 cm long, pyramidal, the branches verticillate, appressed, spreading at maturity, naked at the base, densely flowered, with scattered but rather prominent glandular areas, and a large pulvinus at the base of each; spikelets 1 5–1.7 mm long, short pedicellate, appressed; first glume minute; second glume about as long as the spikelet, abruptly acute or subobtuse, lemma similar to the second glume but somewhat narrower; palea broad, conspicuous, as long as the lemma, minutely dentate, anthers 0 3 mm long, pale or pinkish; caryopsis 1 mm long, asymmetrically obovate, pale lead colored or reddish, the embryo appearing as a blackened area at the base.

Type in the U. S. National Herbarium, no 997877, collected at Adamana, Ariz., August 6–15, 1903, by David Griffiths (no 5107)

This species has been confused with *Sporobolus pyramidatus* (Lam) Hitchc but is easily distinguished by its annual habit, short flat blades, and abruptly acute or subobtuse second glume and lemma. *S. pyramidatus*, described from South America, (as *Agrostis pyramidatus*), is a strong densely tufted perennial with stiff, erect, acuminate blades and spikelets as much as 2 mm long. The second glume and lemma are gradually acute or subacuminate rather than acute or subobtuse, as in *S. pulvinatus*.

Sporobolus pulvinatus is apparently rather common on sandy plains and roadsides of northern Mexico, extending northward to Texas, New Mexico, and Arizona, where it is relatively rare, at least as indicated by herbarium-specimens, and southward to Oaxaca. Specimens representing this species are as follows:

TEXAS: El Paso, *M. E. Jones 4338;* without locality, *Reverchon.* NEW MEXICO: Valencia County, 50 miles west of Albuquerque, *John Redd* in 1935 (Soil Conservation Service no. 755); San Ysidro, Sandoval County, *Dean Mahaffey 83.* ARIZONA: Wilcox, *Griffiths 1896;* Benson, *Griffiths 1490.* SONORA: Agiabampo, *Palmer 814* in 1890; Guaymas, *Palmer 696* in 1887; Batamotal, *Orcutt* in 1899; Imeris to Santa Ana via Magdalena, *Griffiths 6856* CHIHUAHUA: Chihuahua, *Pringle 816.* COAHUILA: Saltillo, *Hitchcock 5580.* TAMAULIPAS: Tampico, *Hitchcock 5789.* SINALOA: Mazatlan, *Purpus 359.* DURANGO: Durango, *Hitchcock 7583, Palmer 384* in 1896; Bernejillo, *Johnston 7787.* QUERÉTARO: Querétaro, *Hitchcock 5855.* HIDALGO: Pachuca, *Hitchcock 6758.* ZACATECAS: Villa de Cos, *Johnston 7427.* OAXACA: Tomellin, *Hitchcock 6236.*

Sporobolus patens Swallen, sp. nov.   Fig. 5

Annuus; culmi 10–25 cm alti, graciles, erecti, glabri; vaginae internodiis breviores, glabrae, in ore sparse hispidae, ea suprema elongata aphylla; ligula ciliata, 0.5 mm longa, laminae 1–2 cm longae, 1–2 mm latae, lanceolatae, planae, marginibus scabris; paniculae pyramidales, 2.5–5 cm longae, ramis paucifloris patentibus infimis subverticillatis superioribus alternis, ramulis abrupte patentibus; spiculae 1.8–2 mm longae, pedicellibus divaricatis usque ad 3 mm longis; gluma prima 0 3 mm longa; gluma secunda et lemma aequalia, acuta; palea lemmate paulo brevior, lata, truncata, minute dentata; antherae 0.2–0.3 mm longae; caryopsis 1 mm longa, pallida.

Annual; culms 10–25 cm tall, slender, erect, in small tufts, glabrous; sheaths shorter than the internodes, the upper one elongate almost bladeless, glabrous, sparsely hispid at the throat; ligule ciliate, about 0 5 mm long; blades 1–2 cm long, 1–2 mm wide, lanceolate, flat, scabrous on the margins; panicles pyramidal, 2.5–5 cm long, the slender branches spreading or even reflexed, the lower ones subverticillate, the upper ones scattered, few flowered, the branchlets abruptly spreading; spikelets 1 8–2 mm long, the pedicels slender, spreading, as much as 3 mm long; first glume minute, about 0 3 mm long; second glume and lemma equal, acute, the lemma a little broader than the glume; palea somewhat shorter than the lemma, broad, truncate, minutely dentate; anthers minute, 0.2–0 3 mm long, pinkish; caryopsis 1 mm long, pale.

Type in the U. S National Herbarium, no. 1723881, collected at Wilcox, Ariz., September 26, 1938, by W. A. Silveus (no. 3504).

Probably closely related to the preceding, differing in having very slender culms, delicate few-flowered panicles, long spreading pedicels, and larger spikelets. The pulvini are inconspicuous and there are no glandular areas on the axis or branches of the panicle.

Andropogon rhizomatus Swallen, sp. nov.   Fig. 6

Perennis, rhizomatosus; culmi 50–70 cm alti, solitarii vel caespitosi, glabri, in parte superiore ramosi, ramis gracilibus appressis vel adscendentibus; vaginae internodiis longiores, obscure carinatae, glabrae, inferiores aphyllae; ligula membranacea, minute erosa, 0 5 mm longa; laminae 10–25 cm longae, 1–3 mm latae, glabrae; spathae angustae inconspicuae; racemi solitarii, 2–3 cm longi, pedunculis gracilibus 3–7 cm longis; rachis tortuosa marginibus villosis; spicula sessilis 5–6 mm longa, gluma prima apice obscure carinata, glabra; lemma fertile 5 mm longum, angustum, arista 8–10 mm longa, geniculata, infra geniculam contorta; spicula pedicellata reducta, 2–3 mm longa, exaristata, pedicello superne ciliato.
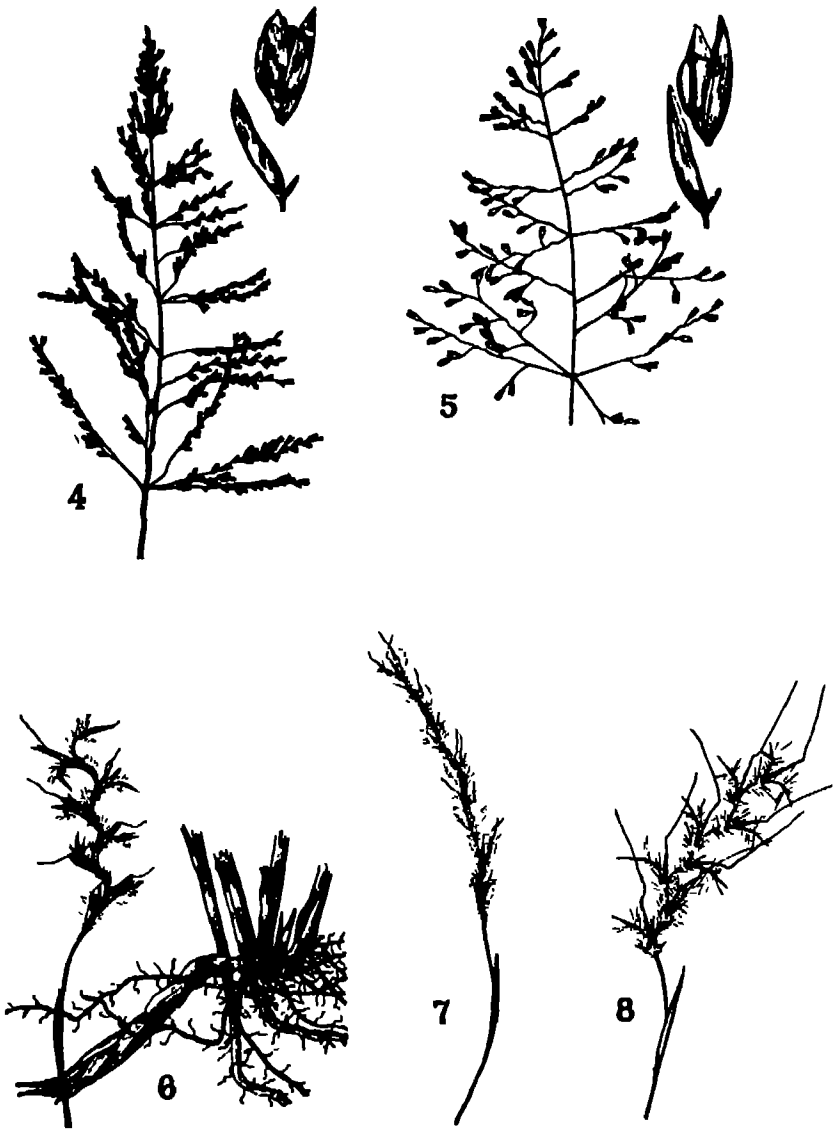
Figs. 4–8.—New species of United States grasses, plants and panicles, ✕1, spikelets, ✕10· 4, *Sporobolus pulvinatus*. 5, *Sporobolus patens;* 6, *Andropogon rhizomatus;* 7, *Andropogon niveus*. 8, *Andropogon sericatus* Drawings from the type specimens by Mrs Frances C. Weintraub

Perennial; culms 50–70 cm tall, slender or rather stout, scattered, or in small dense tufts, erect from short scaly rhizomes, glabrous, rather sparingly branched above the middle, the usually long slender branches appressed or narrowly ascending; sheaths much longer than the internodes, or the upper ones shorter, rounded on the back or obscurely keeled, the lowermost short, crowded, bladeless, but these not always evident; ligule membranaceous,

minutely erose, about 0.5 mm long; blades 10–25 cm long, 1–3 mm wide, flat or loosely involute, glabrous; racemes solitary, 2–3 cm long, partly enclosed or exserted from the very narrow inconspicuous spathes, the peduncles very slender, 3–7 cm long, the rachis tortuous, villous on the margins; sessile spikelet 5–6 mm long, narrow, the first glume rounded on the back, obscurely keeled near the summit, glabrous; fertile lemma 5 mm long, very narrow, awned from about the middle, the awn 8–10 mm long, geniculate, tightly twisted below the bend; pedicellate spikelet very much reduced, inconspicuous, 2–3 mm long, awnless, the pedicel arcuate spreading, villous on the margins above the middle.

Type in the herbarium of the U. S. National Arboretum, no. 98478, collected in shallow rocky soil near Homestead, Fla., October 16, 1940, by W. A. Silveus (no. 6614).

This well-marked species superficially resembles *Andropogon stolonifer* (Nash) Hitchc , which is typically much larger with longer rhizomes, broad, distinctly keeled sheaths, and more numerous racemes which are commonly 4–6 cm long It is a plant of low rocky or alkaline soil of southern Florida, while *A. stolonifer* is found in sandy woods of northern Florida.

Other collections have been made west of Palm Beach, *Silveus 6661*, and Royal Palm State Park, *Silveus 6606*

Andropogon niveus Swallen, sp. nov   Fig. 7

Perennis; culmi graciles 50–65 cm alti, caespitosi glabri; vaginae carinatae, glabrae, inferiores internodiis longiores, superiores internodiis breviores, ligula membranacea, 1 mm longa; laminae 5 9 cm longae, 1–2 mm latae, divergentes vel reflexae, marginibus scabris; racemi 4–7, 3–4 cm longi, rachi subflexuosa densissime pilosa pilis ca 2 mm longis; spiculae sessiles 5–6 mm longae, suberectae; gluma prima minute bifida, obscure carinata, glabra, lemma fertile 4 mm longum, lobatum, arista 1 cm longa, geniculata, infra geniculam contorta, spicula pedicellata reducta 3 mm longa

Perennial; culms slender, 50–65 cm tall, in small rather dense tufts, erect, glabrous; sheaths keeled, glabrous, the lower ones longer, the upper ones shorter than the internodes; ligule membranaceous about 1 mm long; blades 5–9 cm long, 1–2 mm wide, flat, scabrous on the margins, spreading to reflexed; racemes solitary, few to several, 3–4 cm long, terminating the slender, elongate, rather distant branchlets, the rachis nearly straight or somewhat flexuous, the joints and sterile pedicels about 5 mm long, very densely villous, the hairs 2 mm long at the summit becoming gradually shorter toward the base; first glume of sessile spikelet 5–6 mm long, glabrous, minutely bifid, obscurely keeled toward the summit, 2-nerved between the keels; fertile lemma 4 mm long, very deeply lobed, awned from near the base, the awn 1 cm long, geniculate at the middle, tightly twisted below the bend; pedicellate spikelet much reduced, about 3 mm long including the awn; anthers yellow, 2 5 mm long.

Type in the herbarium of the U. S. National Arboretum, no 98477, collected on sandy land about 15 miles south of Kissimmee, Fla , October 21, 1940, by W. A Silveus (no 6684)

This very graceful species is allied to *Andropogon gracilis* Spreng., which can be distinguished by the longer involute blades, more conspicuously hairy racemes, and stouter longer awns as much as 2 cm long It is rather common in open sandy pineland of central Florida Other collections than the type have been made in Florida east of Clermont, Lake County, *Silveus 6704*, Gainesville, Alachua County, *Swallen 5634, 5639;* 8 miles east of Dundee,

Polk County, *McFarlin 3707;* Brooksville, Hernando County, *H. R. Reed* in 1933.

Andropogon sericatus Swallen, sp. nov.   Fig. 8

Perennis; culmi graciles, 50–80 cm alti, erecti, caespitosi, in parte superiore multiramosi, ramis gracilibus erectis vel adscendentibus; vaginae glabrae, carinatae, internodiis breviores, ligula membranacea, truncata, 1 mm longa, laminae innovationes subfiliformae, 10–20 cm longae, supra ad basin pilosae, eae culmorum 15–20 cm longae, 2–3 mm latae, conduplicatae marginibus scabris; spathae inconspicuae; pedunculi 4–6 cm longi, gracillimi, curvati; racemi solitarii, 3 cm longi, vix exserti; rachis gracilis, flexuosa, dense pilosa pilis usque ad 7 mm longis; spicula sessilis 5 mm longa, divergens; gluma prima sulcata carinis scabris; lemma fertile 3 mm longum, bilobum, arista 15–20 mm longa, geniculata, infra geniculam contorta; spicula pedicellata reducta, 3–4 mm longa.

Perennial; culms 50–80 cm tall, rather slender, tufted, erect, glabrous, profusely branching in the upper half, the slender branches and racemes forming a somewhat dense but delicate inflorescence, sheaths, except the lower ones, shorter than the internodes, keeled, glabrous; ligule membranaceous, truncate, 1 mm long, blades of the innovations very narrow or subfiliform, 10–20 cm long, long pilose on the upper surface toward the base; culm blades broader, 2–3 mm wide, conduplicate, mostly 15–20 cm long, scabrous on the margins; spathes very inconspicuous; peduncles 4–6 cm long, very slender, curved but becoming straight with age; racemes solitary or rarely paired, 3 cm long, scarcely exserted from the spathes, the rachis slender, flexuous, conspicuously hairy, the hairs at the summit of the joints as much as 7 mm long, gradually shorter downward, the sterile pedicels spreading, hairy like the rachis joints; sessile spikelets 5 mm long, spreading; first glume conspicuously keeled with a deep furrow between the scabrous keels; lemma 3 mm long, bilobed, awned from just below the middle, the awn 15–20 mm long, geniculate, tightly twisted below the bend; pedicellate spikelet very much reduced, 3–4 mm long including the awn.

Type in the herbarium of the U. S. National Arboretum, no 98479, collected on Ramrod Key, Fla , October 17, 1940, by W A Silveus (no. 6633).

The relationship of this grass is not evident. The racemes are mostly solitary as in the section *Schizachyrium,* but occasionally they are paired as in the section *Arthrolophis,* thus breaking down the primary character used to separate *Schizachyrium* as a genus Superficially this species resembles larger plants of *A. gracilis* Spreng , the racemes of which are fewer and much more conspicuously hairy, and all the blades are involute The numerous slender branches forming a relatively dense but delicate inflorescence, and the usually solitary, flexuous, silky racemes are characteristic.

ZOOLOGY.—*A review of the snakes of the genus* Ficimia.[1] HOBART M. SMITH, Smithsonian Institution, and EDWARD H. TAYLOR, University of Kansas. (Communicated by HERBERT FRIEDMANN.)

In 1936 Taylor[2] reviewed most of the species of *Ficimia* known from Mexico, including a very distinct new species discovered by him in Sonora (*desertorum*). This review was based on material available in the EHT-HMS collection and of necessity was not complete.

While the collection of the U. S. National Museum also lacks certain species (*desertorum, quadrangularis, ruspator*), it does contain a number of specimens that present new and noteworthy information on distribution and variation of other species in the genus. This material, combined with that now present in the EHT-HMS collection, makes possible a redefinition of the several species and an evaluation of certain specific and generic characters of species and groups of species.

Two groups are apparent in *Ficimia* (*sensu lato*), one (*olivacea* group [= *Ficimia, sensu stricto*]) containing *publia, variegata,* a new species described below as *ruspator, olivacea,* and *streckeri,* the other (*cana* group [= *Gyalopion*]) containing *cana, quadrangularis,* and *desertorum.* The association of the latter with the *cana* group is open to question, since the species has two characters that (if normal) distinguish it from all others, not only of the group, but of the genus (entire anal, a loreal[3]). However, it agrees with the *cana* group in pattern and in having the rostral separated from the frontal by contact of the prefrontals. The latter is one of the chief characteristics of the *cana* group, and since *desertorum* seems to be directly ancestral to the other two species of the group, there is little gained by placing it in another group or genus.

The two groups differ from each other in contact (or separation) of the rostral from the frontal and in number of ventrals and subcaudals. The *olivacea* group has the rostral in contact with the frontal, ventrals 140 to 160, and caudals 32 to 42. The *cana* group has the rostral separated from the frontal by contact medially of the two prefrontals, and has 129 to 146 ventrals and 23 to 36 caudals. No hemipenial differences are discernible, and differences in dentition are slight (see following discussion).

The members of the *olivacea* group are differentiated by variations

in pattern (presence, absence, number, and width of blotches), by presence or absence of internasals, and by number of postoculars. Every member (with one exception) has a distinctive pattern, which fortunately is subject to less intraspecific variation (without interspecific overlap, so far as now known) than the two varying characters of scutellation (which do overlap interspecifically). Accordingly pattern is the primary medium of differentiation in the process of speciation in the genus. Scutellation is more generally constant throughout the group, is less readily affected than pattern, and differentiations that have occurred in it are less well stabilized. In both pattern and scutellation, however, there is a definite, orthogenetic trend toward reduction and simplification.

In the *cana* group also pattern is the chief medium of species differentiation. *F. cana* and *quadrangularis* are differentiated from each other largely by pattern characters resulting from two different modes of reduction from a pattern type such as possessed by *desertorum*. Differentiation in scutellation has also occurred, however, and by the same process (simplification by fusion, the loreal of *desertorum* rarely present in *cana* and *quadrangularis*, fused with the prefrontal), carried out during long periods of isolation (i.e., separation from parent stock), as in the *olivacea* group. In both pattern and scutellation *desertorum* is the most primitive of the group. If we regard this species as representing a type ancestral to the other two species, then the two orthogenetic trends evident in the *olivacea* group are quite as obvious in the *cana* group.

In the center of dispersal of the *olivacea* group is *publia*, which we believe is the most primitive of that group, since it is the only one normally with internasals; its pattern is also one from which the other pattern types conceivably may have been derived. The trends of evolution in the group are toward elimination of the blotched pattern (through production of many small spots) and fusion of the head scales. Essentially two lines of divergence, each showing these trends of evolution, from the *publia* stock, are evident: one on the Atlantic coast, marked by extremes of fusion of head scales and of pattern reduction, and one on the Pacific coast, marked by lesser pattern reduction and little fusion of head scales. The Pacific coast branch is now split into two geographic (and specific) populations, one south (east) of the Isthmus of Tehuantepec (*variegatus*), the other north (west) of the Isthmus (*ruspator*). In the Isthmus itself is *publia*. In this line pattern reduction has proceeded but little; the dorsal spots are well defined, and only more numerous and a little narrower than

in *publia*. In scutellation also little change has occurred, the northern form retaining the scutellation of *publia*, the southern form losing the internasals (by fusion with the prefrontals).

Two species (*streckeri* and *olivacea*) have emerged from the Atlantic coast branch also, but in this the pattern is totally eliminated in one (*olivacea*), nearly so in the other (*streckeri*); both have lost the internasals, and *streckeri* marks the extreme in structural specialization in the genus by fusion of the two postoculars.

In the *cana* group, by its possession of a loreal and a generalized pattern, *desertorum* should be ancestral to *cana* and *quadrangularis*; its central geographic position in Sonora supports this view. Its entire anal (apparently a specialized character) may have developed after the evolution of *cana-quadrangularis* stock (in which case each stem possesses a specialized character in scutellation), or unfortunately it may be an aberrant character appearing in the single known specimen.

It is obvious from the foregoing discussion that two widely different stocks, long isolated from each other, are at present included in *Ficimia*, in the arrangement proposed by Boulenger (Cat. Snakes, vol. 2, 1894). These have different centers of dispersal (Fig. 11), different ranges, and different morphological characters, and while obviously related their common ancestry seems very remote. They are units possessing the characters defining them as genera according to present usage of that term; they fit that definition much better than some genera at present generally recognized. Accordingly the eight species of these two units are segregated in the genera *Gyalopion* and *Ficimia*.

Genus Gyalopion Cope

Gyalopion Cope, Proc Acad. Nat. Sci. Philadelphia, 1861, p. 243.

Genotype.—Gyalopion canum Cope, *loc. cit*, by monotypy.

Diagnosis.—Maxillary teeth 12 to 15, subequal, no diastemata, some with very distinct, shallow, lateral depressions, all or most others with some evidence of same; body short, cylindrical, head not distinct from neck, eye small; pupil round; snout projecting, pointed; rostral large, separated from frontal by prefrontals; internasals present; loreal present or absent; anterior section of nasal usually fused with first labial; one anterior temporal; posterior chinshields very small; scales smooth, with single apical pits; ventrals 129 to 146; caudals 23 to 36; hemipenis undivided, distal half or two-thirds calyces, a small adjacent (proximally) area spines, basal sixth ridges, sulcus single.

Remarks.—Because of the constant presence of internasals, presence of a loreal in two specimens, and constant separation of the rostral from the frontal, this genus is, in general, more primitive than *Ficimia*. That it is not directly ancestral to it is attested by the peculiar pattern, reduced ventral and caudal count, and peripheral distribution (with a different center of dispersal).

Gyalopion desertorum (Taylor)   Figs. 2, 7, 15

Ficimia desertorum Taylor, Proc. Biol. Soc. Washington 49: 51–52. 1936 (12
    kilometers northwest of Guaymas, Sonora); Kansas Univ. Sci. Bull. 24:
    494, pl. 43, fig. 1. 1936 (1938).

Diagnosis.—Rostral separated from frontal by prefrontals; a loreal; anal
single (normal?); blotches entirely black on middorsum; nuchal spot extend-
ing onto frontal and supraocular region; ground color reddish, except on mid-
dorsum.

Specimens examined.—One, the type, the only known specimen (EHT-
HMS 4576).

Remarks.—From *canum* and *quadrangularis* this species differs by possessing
a loreal, perhaps in having a single anal, and in color pattern. The latter is
more like that of *quadrangularis* than *canum*, since in both the spots are uni-
form black (not brown, black-edged as in *canum*) and the nuchal spot is
fused across the middorsal occipital region with another black spot on the
top of head which involves the frontal and extends laterally through and be-
low the eyes.

In *quadrangularis*, however, the spots are less numerous (26 on body, 5 on
tail; in *desertorum*, 32 on body, 8 on tail), and they are restricted to the mid-
dorsal region, the sides being unmarked In *desertorum* the blotches extend
laterally to the edge of the ventrals, but on the sides of the body a broad, cen-
tral area of each scale in the blotches is light, the dark area restricted to the
edges of the scales Only the nuchal blotch is uniform black on the sides of
the body.

The reddish (magenta) dorsal ground color (cream on middorsum) of
desertorum is a very noteworthy and surprising development This color is
very striking in life, although not evident after six years in preservative: the
local residents called the snake a coralillo Since red occurs in no other species
of either *Gyalopion* or *Ficimia* (so far as now known; *quadrangularis* may
have it), its significance is not readily obvious Presumably it is a specializa-
tion.

The maxilla has 13 subequal teeth, most of them feebly grooved laterally;
extreme anterior tip toothless.

The hemipenis is 10 caudals long, distal three caudal lengths calyces; ad-
jacent five caudal lengths spines, the size increasing proximally; two large
basal spines; remaining area at base ridged, each ridge surmounted by tiny
spines; sulcus single.

G. desertorum differs from all others of its genus and of *Ficimia* (so far as
known) in the presence of tiny spines on the proximal portion of the hemi-
penis, and by the presence of a loreal (latter not completely unique). With
some reason the species could be separated in a monotypic genus, especially if
the single anal proves constant. We have refrained from doing so because it
appears to be directly ancestral to *canum* and *quadrangularis*.

Gyalopion quadrangularis (Günther)

Ficimia quadrangularis Günther, Biol. Centr. Amer., Rept., p. 99, pl. 35,
    fig. A. 1893 (Presidio, near Mazatlán, Sinaloa).

Diagnosis.—Rostral separated from frontal by prefrontals; no loreal; anal
divided; no spots on sides of body, only markings a series of 26 rounded or
subquadrangular, uniform blackish-brown spots on body, 5 on tail; spots not
extending below fifth scale row, sides of body below this nearly white; nuchal
spot confluent with interocular dark bar.
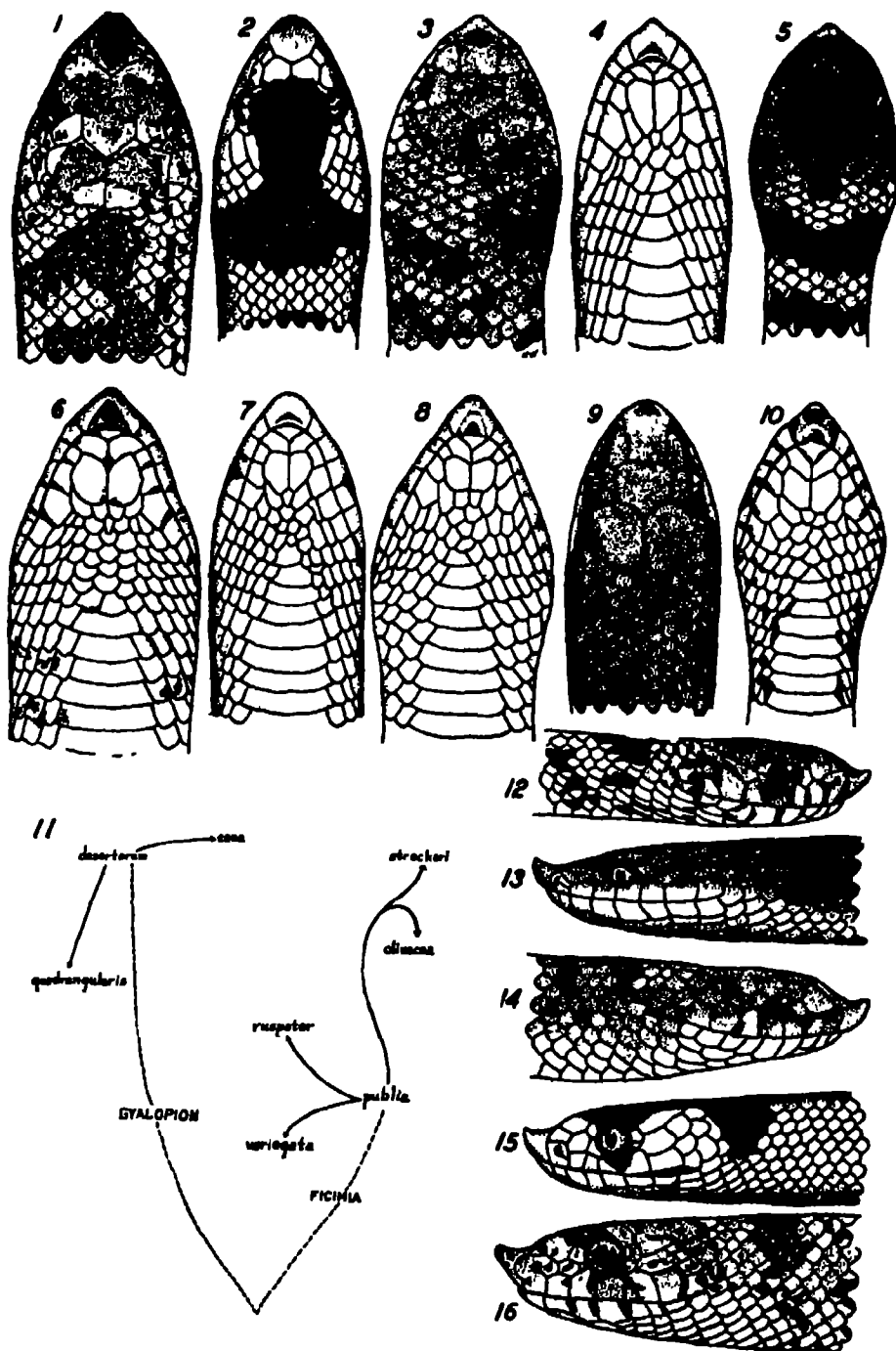
Fig 1 —(See opposite page for legend).

Specimens examined.—None. Apparently none in American museums; type in British Museum.

Remarks.—This species does not differ from *canum* in scutellation. Günther points out that the seventh labial is very small, but the size of this scale varies greatly at least in *Ficimia publia*, and possibly also in *quadrangularis*. Some *publia* have it considerably smaller than the tertiary temporals (as in *quadrangularis*), others have it much larger.

Pattern differences from *canum* are obvious; spots fewer (30 to 39 in *canum*), head markings black, fused with first nuchal spot (not in *canum*), no marks on sides (secondary spots on sides in *canum*, dorsal spots also extending on sides), all spots black (brown, black-edged, in *canum*). It has fewer spots than *desertorum*, and the spots are restricted to the middorsal region, but otherwise it is much like the latter, from which its pattern obviously is derived.

Gyalopion canum Cope   Figs. 1, 6, 16

Gyalopion canum Cope, Proc. Acad. Nat. Sci. Philadelphia, 1860, p 243 (Fort Buchanan, Ariz.; U.S.N.M. nos. 16427–8).

Ficimia cana Garman, Mem. Mus Comp. Zool. 8: 83, 161 1883; Van Denburgh, Occ. Papers California Acad. Sci. 10· 777–779. 1922; Taylor, Copeia, 1931, no. 1, pp. 4–5.

Diagnosis.—Rostral separated from frontal by prefrontals; no loreal; anal divided; spots on body 30 to 39, on tail 9 to 12; spots brown, black-edged, broken laterally or continuous with lateral spots, reaching nearly to ventrals; irregular, small spots scattered on sides of body.

Specimens examined.—Four.

Range.—Southeastern Arizona east to Tom Green County, Tex , south to the Chisos Mountains, Tex. Not yet recorded from Mexico.

Locality records.—ARIZONA: Fort Buchanan (U.S.N M nos. 16427–8); Montezuma Canyon, Huachuca Mountains (Van Denburgh) NEW MEXICO: White Sands, Alamogordo (Van Denburgh); 10 miles north of Florida, Luna County (Kans. Univ nos. 6616–7). TEXAS: Green Gulch, Chisos Mountains (U.S.N.M. no. 103654); Tom Green County (Baylor Univ. no. 6015); El Paso (Van Denburgh).

Remarks.—The color pattern of this species is markedly different from that of the other two species of the genus in having the blotches light-centered and black-edged, and a different head and neck pattern An interocular dark bar, bordered by light anteriorly and posteriorly, is visible in this species; a similar bar extends across the middle of the parietals, the nuchal blotch does not extend onto the head. The pattern is conceivably derived from that of *desertorum*, in which the blotches number about the same, but are solid black. The

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Figs. 1, 6, 16.—Cephalic scutellation of *Gyalopion canum*, from K U. no 6616, Florida, N. M. Loreal and small lower preocular not usually present.
Figs. 2, 7, 15.—Cephalic scutellation of *Gyalopion desertorum*, from holotype, EHT-HMS no. 4576, Guaymas, Sonora
Figs. 3, 8, 14.—Cephalic scutellation of *Ficimia streckeri*, from holotype, K U no 9140, Rio Grande City, Tex
Figs 4, 9, 13.—Cephalic scutellation of *Ficimia olivacea*, from EHT-HMS no 4575, Tierra Colorada, Veracruz.
Figs. 5, 10, 12.—Cephalic scutellation of *Ficimia ruspator*, from holotype, EHT-HMS no. 23646, Tixtla, Guerrero.
Fig. 11.—Diagrammatic representation of the possible phylogeny of *Gyalopion* and *Ficimia*.

latter feature seems to be the primitive condition in *Ficimia* as well as in *Gyalopion*, since southern (presumably most primitive) *publia* have the spots nearly or quite solidly black.

TABLE 1.—VARIATION IN GYALOPION CANUM

Number	Sex	Ventrals	Caudals	Supral	Infral	Proc	Ptoc	Ptoc	Body spots	Tail spots
6617	♂	134	35	7-7	7-7	1-1	1-2	1-1	39	12
103654	♂	136	30	7-7	7-7	1-1	2-2	1-1	34	12
5284	♀	136	27	7-7	7-8	1-1	2-2	1-1	30	9
6616	♀	143	31	7-7	8-8	2-2	2 2	1-1	36	9
6015	♀	141	31	7-7	7-7	1-1	2-2	1-1	36	11
Brit M	♀	131	28	7-7		1-1	2-2	1-1		
Ruthven	♀?	145	29	7-7	7-8	1-1	2-2	1-1	40	9

Maxilla with 12 teeth, all with moderately distinct to faint, lateral depressions or grooves; tip toothless.

Hemipenis (of K.U. no 6617) about 14 caudals long; distal half calyces, these extending a little farther proximally along sulcus; nearly all of remainder spines; two large basal spines; extreme basal portion ridged, without spicules.

One specimen (no. 6617) has the first labial completely separated from the nasal. Another from the same locality has a loreal and a small, lower preocular (Fig. 16).

Genus Ficimia Gray

Ficimia Gray, Cat. Snakes Brit. Mus , p. 80. 1849
Amblymetopon Günther, Cat. Snakes Brit. Mus., p. 7. 1858 (genotype, *variegatum*, by monotypy).
Genotype.—*Ficimia olivacea* Gray, loc. cit., by monotypy.
Diagnosis.—Like *Gyalopion*, except: Maxillary teeth with very faint lateral grooves or depressions; rostral in contact with frontal, separating prefrontals medially; loreal absent; internasals present or absent (fused); ventrals 140 to 160, caudals 32 to 42.

Ficimia publia Cope

Ficimia publia Cope, Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 126 (Yucatán; two cotypes, U.S.N M. nos. 16427-8); Barbour and Cole, Bull Mus. Comp. Zool. 50: 153. 1906; Taylor, Proc. Biol. Soc. Washington 49: 53. 1936; Schmidt and Andrews, Field Mus Nat. Hist., zool. ser , 20: 173-174. 1936; Hartweg and Oliver, Univ. Michigan Mus. Zool. Misc. Publ 47: 23 1940.
?*Ficimia olivacea (sensu lato, nec* Gray) Stuart, Univ. Michigan Mus. Zool. Misc. Publ. 29: 51. 1935.
Ficimia variegata (nec Günther) Taylor, Proc. Biol. Soc. Washington 49: 54. 1936.
Diagnosis —Rostral in contact with frontal; internasals usually present (84 percent), two postoculars, or if only one, the other obviously fused with it or with supraocular; a dorsal pattern of distinct blotches or irregular bands, 21 to 35 on body, 7 to 11 on tail; centers of blotches usually lighter, edges black (all black only in southern [Honduras] specimens); length of blotches equal to two to four scale lengths; spaces between blotches never exceeding one and one-half times length of blotches, usually equal or less.

Specimens examined.—Fourteen. Partial data on four others.

Range.—Isthmus of Tehuantepec to western Honduras; on Pacific slopes only from the Isthmus of Tehuantepec to southern Guatemala.

Locality records.—CHIAPAS: La Esperanza, near Escuintla (U S.N.M. no. 110296). OAXACA: Ranchero Pozo Río (U.M.M Z. no. 82594); La Concepción (U.S.N.M. no. 110298); Tehuantepec (U S.N.M. no. 110297) VERACRUZ: Minatitlán (Taylor). YUCATÁN: Catmis (F M.N.H. no. 26993); Chichen Itza (F.M.N.H. nos. 20623, 20653; M C Z , Barbour and Cole); Yucatán (U.S.N.M. nos. 16427-8; Brit. Mus) GUATEMALA: ?La Libertad (U.M.M.Z., Stuart); Piedras Negras (U.S.N.M. no. 110295); Escuintla (U S.N.M. 12688). HONDURAS: Ceiba (U.S N M. nos. 55237-8, 64986). One other record is Cuernavaca, Morelos (Brit. Mus.). While this may be correct, its distant removal from other localities represented by the species makes it questionable, until supported by other locality data If the locality is correct, the specimen very likely may be referable to *ruspator*. It has internasals.

Remarks —It is our belief that the chief character identifying this species and separating it from its nearest relatives is its pattern It has less numerous blotches than *variegata* and *ruspator* (which have nearly identical patterns), and much broader and more regular ones than *streckeri; olivacea* has none.

The head markings show a great deal of variability They are symmetrical and well defined in the Tehuantepec specimens, absent in the Honduras specimens, and present, although asymmetrical and not well defined, in the others.

The presence or absence of internasals is not an infallible, invariable character in this group. While *publia* is generally characterized by internasals present, the fact that one specimen has one internasal partially fused with the prefrontal and another specimen has one internasal on one side, leads us to believe that the two specimens lacking internasals on both sides are merely variants of *publia* The latter two specimens show no differences in pattern, and no differences we can consider significant in scutellation, from other *publia*. Both occur within the expected range of *publia*

Species in which the internasals have been lost do not show a variation like that which occurs in *publia:* 14 specimens of these species (*streckeri, olivacea, variegata*) show the occurrence of an internasal but once (on one side of one *olivacea*). Since the trend in this genus is toward loss of these scales, it is to be expected that the variation should occur in those retaining the scales distinct (*publia, ruspator*), not in those in which they are lost; distinct internasals are an anomaly in the latter, but the lack of them in the former is merely evidence of a well-established generic trend This fact is one of the chief reasons that *ruspator* is held distinct from *variegata*, which is known to normally lack internasals (none in four specimens).

As shown in Table 2, the relative width and length of frontal, rostral, and frontal-rostral suture seem to have no great significance in *publia*, except that the frontal-rostral suture may be broader in younger specimens, and that the rostral is generally a little shorter than the frontal.

If other forms are distinguished in the future among the specimens here referred to *publia*, we believe they will be subspecies distinguished by features of the color pattern. The most distinct population now discernible is that of Honduras; the three specimens from that country have the blotches bandlike and of uniform color throughout, the ground color light (not darkened), and very few lateral marks. All other *publia* have the blotches - distinctly light centered; the condition of the Honduras specimens is closely

TABLE 2 —VARIATION IN FICIMIA PUBLIA

Number	Sex	Ventrals	Caudals	Supral.	Infral.	Proc.	Ptoc.	Intern	Rostrofrontal suture	Rostral width	Rostral length	Frontal length	Body spots	Tail spots	Gen. loc.
									mm	mm	mm	mm			
55237	♂	144	38	7-7	8-8	1-1	2-1	0-1	0 9	2 0	2 3	3 0	28	9	Honduras
55238	♂	144	39	7-7	7-8	1-1	2-1	1-1	1 0	1 9	2 8	3 1	31	10	Honduras
Stuart	♂	135	36												Peten
110295	♂	146	38	7-7	8-8	1-1	2-2	1-⅓	1 2	2 8	4 0	4 0	27	8	Peten
16428	♂	134	33	7-7	7-7	1-1	2-2	1-1	0 7	2 0	2 8	2 8	31	11	Yucatán
28993	♂	136	37	7-7	7-7	1-1	1-2	0-0					25	8	Yucatán
M C Z	♂?	145	37					1-1					26	9	Yuratán
Brit M	♂?	142	36			1-1	2-2	1-1							Yucatán
82504	♂	143	30	7-7	7-7			1-1					25	8	Tehuantepec
64086	♀	156	35	7-7	7-8	1-1	1-2	1-1	0 9	1 8	2 1	2 9	30	9	Honduras
16427	♀	138	30	7-7	7-8	1-1	2-2	1-1	0 7	1 9	2 6	2 7	31	10	Yucatán
20623	♀	148	35	7-7	7-7	1-1	2-2	1-1					26	9	Yucatán
20635	♀	151	32	7-7	6 7	1-1	2-2	1-1					25	7	Yucatán
Ruskard	♀	155	34	7-7	7-7	1-1	1-1	0-0			5 1	4 4	32	9	Veracruz
110207	♀	148	32	7-7	7-7	1-1	2-2	1-1	1 7	1 9	2 0	2 2	21	7	Tehuantepec
110208	♀	152	37	7-7	8-8	1-1	2-2	1-1	1 0	1 8	2 0	2 2	25	7	Tehuantepec
110206	♀	153	36	7-7	7-8	1-1	2-2	1-1	1 2	2 8	4 5	3 8	31	8	Chiapas
12088	♀	154	32	7-7	8-8	1-1	2-2	1-1	0 9	2 1	3 8	3 5	35	9	Guatemala
Brit. M	♀	142	35					0-0							"Mexico"

approached by the Piedras Negras specimen, in which the blotches are almost entirely black. We have refrained from naming the Honduras specimens because it appears certain that, if they are recognized, then the remainder of *publia* should be split: the Yucatán specimens have few marks on the sides, the Escuintla specimen has the blotches bandlike; and the remainder have the blotches split laterally (not forming crossbands), numerous lateral spots, and adults have the ground color darkened. Until these pattern types are known from many more specimens, and the limits of variation can be more definitely established, it is impossible to diagnose subspecies in *publia* with any degree of certainty.

<p align="center">Ficimia ruspator sp. nov.   Figs. 5, 10, 12</p>

?*Ficimia publia* Boulenger, Cat. Snakes Brit. Mus. 2: 271. 1894. (*part.*; the Cuernavaca specimen).

Holotype.—E. H. Taylor–H. M Smith collection no. 23646, female, 3 miles east of Tixtla (about 10 miles east of Chilpancingo), Guerrero.

Diagnosis.—Similar to *Ficimia publia*, but blotches on body 43, on tail 11. Similar to *Ficimia variegata*, but internasals present. Two postoculars; blotches narrow, tending to be light-centered; ventrals 154; caudals 33.

Description of holotype.—Rostral large, elongate, its suture with frontal subequal to sutures between latter and prefrontals; rostral sharply upturned anteriorly, the ridge bordered posteriorly by a shallow depression; length of rostral from anterior ridge to frontal (2.3 mm) distinctly greater than length of frontal (2.0 mm), very slightly greater than length of median parietal suture; nasal narrow, anterior section fused with first labial; prefrontal in contact with second labial; preocular single, large; two postoculars, lower

smaller; one elongate, narrow, anterior temporal; two (three) tertiary temporals; seven supralabials, all relatively high, sixth largest, fourth next largest, third and fourth contacting orbit, seventh slightly larger than lower tertiary temporal; diameter of orbit nearly as great (five-sixths) as its distance from labial border, little less than half its distance from tip of snout; seven infralabials, fourth largest, three in contact with anterior chinshields; posterior chinshields practically indistinguishable, separated medially by two scales, somewhat larger than gular scales, in contact with two labials.

Scales in 17 rows throughout, smooth, with single apical pits; ventrals 154; anal divided; caudals 33 Total length 144 mm; tail 20 mm.

Color.—General color light gray; body with 43 transverse, black blotches, some of the anterior blotches with dimly lighter (brown) centers; blotches broken on sides of body at about fifth scale row, below this sides with irregular black spots and vertical streaks, some rarely confluent with dorsal blotches, some involving ends of ventrals; spaces between blotches about equal to length of blotches or slightly less (one and one-half to two scale lengths, middorsal line); tail with 11 dorsal crossbars, sides with a very few spots. Top of head somewhat brownish gray, with numerous irregular black marks, a large dark spot under eye, reaching lip; labial sutures dark. Infralabial sutures dark stippled, the markings not distinct; no other gular marks; some spots on sides of body involving ends of ventral; a little scattered stippling on sides of belly; otherwise ventral surfaces unspotted, white.

Remarks —Aside from the "Cuernavaca" record of Boulenger, which is open to much doubt, the type of *ruspator* is the only specimen of *Ficimia* known from the Pacific slopes of Mexico north (west) of Tehuantepec. The fact that this area faunistically is much different from the area in Chiapas and southeastern Oaxaca inhabited by *variegata;* that the range of the latter species is separated from the presumed range of *ruspator* by an area (Tehuantepec) occupied by *publia;* that species of *Ficimia normally* lacking internasals very rarely (if ever) have them on both sides (it is the reverse that frequently occurs); and that *Ficimia* tends to differentiate in each different area it inhabits, leads us to believe that the single specimen and type of *ruspator* may be normal and represent a form different from *variegata* (by presence of internasals) and *publia* (by more numerous blotches). If further specimens prove to lack internasals usually, then the concept of the range of *variegata* must be extended to include this area, in spite of the fact that it is split in the Tehuantepec area by the range of *publia.* That we do not believe this will prove to be the case is implied by the fact that the Guerrero specimen is here named. We believe that *ruspator* and *variegata* are of independent origin (from *publia,* however), and that the parallelism between the two in pattern is explicable by the orthogenetic trend in the genus toward reduction in size and increase in number of the blotches. Probably *streckeri* passed through the same stage in its pattern evolution, which in it has gone still farther and produced very narrow, irregular bands The fact that *variegata* has lost the internasals while *ruspator* retains them indicates a possibly greater age for the former.

The parallelism between *ruspator* and *variegata* is remarkably similar to that occurring in *Conophis lineatus* and *C. pulcher.*

Ficimia variegata (Günther)

Amblymetopon variegatum Günther, Cat. Snakes Brit. Mus., pp. 7–8. 1858 (Mexico).

†*Ficimia olivacea* Steindachner, Sitzb. Akad. Wiss Berlin 61: 19. 1870; Günther, Biol. Centr. Amer., Rept., p. 98 1893 (part), pl. 35, fig. C; Boulenger, Cat Snakes Brit. Mus. 2: 272. 1894 (part).

Diagnosis.—Rostral in contact with frontal; apparently no internasals normally; two postoculars normally; pattern consisting of 45 to 56(?) band-like blotches on body, about 16 on tail; bands covering one and one-half to two scale lengths medially; spaces between bands about equal to length of bands.

Specimens examined—One Four known.

Range—Mountains of central Chiapas and eastern Oaxaca (i.e., east of the Isthmus of Tehuantepec).

Locality records—The single specimen examined is from Guichicovi, Oaxaca. If the Steindachner specimen from "Tustla" is properly associated with this species, the locality more correctly may be Tuxtla Gutierrez, Chiapas (as previously stated by one of us Taylor, *loc cit.*, 1936, p. 54]). The cotypes collected by Sallé very likely came from this same region, as a number of other species of reptiles collected by him are now known to be restricted to that area

Remarks.—If *variegata* has any significance whatever, the name must be applied to specimens with a large number of dorsal blotches The fact that the four specimens now known with numerous blotches all appear to have originated from a rather well-defined area not occupied by other members of the genus (except perhaps *olivacea*, the range of which may overlap that of *variegata*), correlated with the fact that all four lack internasals while the species' closest relatives (*publia, ruspator*) normally have them (in spite of the general trend in the genus toward elimination of them), indicates a natural association and not a purely arbitrary one.

The specimen examined has 48 bands on the body, 16 on the tail Descriptions of other specimens of the species unfortunately do not make clear whether the band count given is the total number or only those on the body The figure in Günther (Biol. Centr Amer) of one of the cotypes shows about 45 on the body, about 16 on the tail (total 61) However, Günther states that there are "51 to 56 of these crossbars," but leaves indefinite what these numbers represent Since neither number corresponds either to body or total blotches shown in the figure, perhaps the latter is incorrectly executed. The original description does not clarify the situation, as the specimen described in detail is merely said to have "56 black narrow cross bars."

The Guichicovi specimen is a female; ventrals 152, caudals 36; supralabials 7–7; preoculars 1–1, postoculars 1–2 (upper fused with supraocular on one side); no internasals, rostro-frontal suture 1.2 mm; rostral width 2.7 mm; rostral length 3 8 mm, frontal length 3 9 mm. The two specimens in the British Museum (a juvenile and a female) have 160 and 149 ventrals, respectively, 37 and 36 caudals; both have 1–1 preoculars and 2–2 postoculars.

<center>Ficimia olivacea Gray   Figs. 4, 9, 13</center>

Ficimia olivacea Gray, Cat Snakes Brit Mus., p. 80. 1849 (Mexico), Sumichrast, La Naturaleza 6: 41 1882, Taylor, Proc Biol. Soc Washington 49: 52–53. 1936

Diagnosis—Rostral in contact with frontal; internasals normally absent; two postoculars, or if only one, the other obviously fused with it or with supraoculars; uniform dark gray or brown above, no evidence of transverse markings.
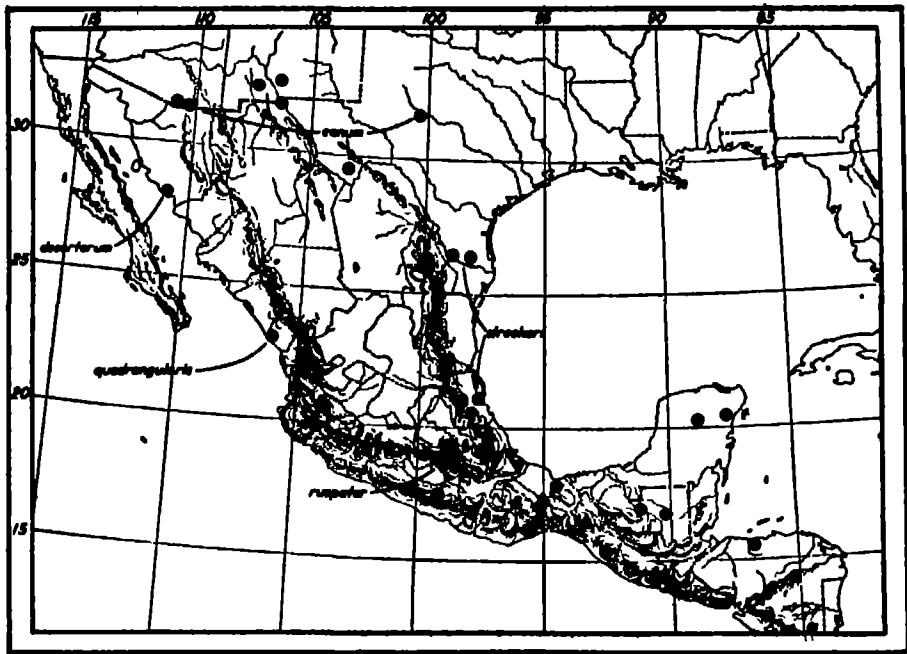
Fig 17—Geographic distribution of the species of *Gyalopion* and *Ficimia*
Inverted triangles, *olivacea*, triangles not inverted, *variegata*, solid circles not otherwise
indicated, *publia*

Specimens examined.—Four. Two others reported.
Range —Central and southern Veracruz in coastal regions and low hills
(not to coast in extreme southern Veracruz); northeastern Oaxaca.
Locality records.—OAXACA. El Barrio, near Lagunas (U.S.N M. no.
30131). VERACRUZ: Orizaba (U S N.M. no. 6329); Otopa (F.M N.H. no
1315); Tierra Colorada (EHT-HMS 2194).
Remarks.—The species is well defined, since it is the only one without
dorsal spots

TABLE 3 —VARIATION IN FICIMIA OLIVACEA

Number	Sex	Ventrals	Caudals	Supral	Infral	Proc	Ptoc	Intern
6329	♂	140	37	7-7	7-7	1-1	2 2	0-0
Brit M	♂	152	42			1-1	2-2	0-0
Brit M.	♂	150	41			1-1	2-2	0-1
2194	♂	142	38	7-7	7-7	1-1	2-2	0-0
30131	♀	146	37	7-7	7-7	1-1	2-2	0-0
1315	♀	142	37	7-7	7 7	1-1	2-2	0-0

Maxilla (no. 6329) with 15 subequal teeth, almost all with moderately well
defined, lateral grooves. Hemipenis of same specimen nine caudals long,
distal half calyces; nearly all of remainder with spines, increasing in size
proximally and terminating with two larger basal spines; extreme basal
portion ridged, spineless; sulcus single.

<div align="center">

Ficimia streckeri Taylor Figs. 3, 8, 14

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Ficimia streckeri Taylor, Copeia, 1931, no. 1, pp. 5–7 (3 miles east of Rio Grande City, Tex).

Diagnosis.—Rostral in contact with frontal; normally no internasals; one postocular; pattern consisting of numerous (38 to 47), narrow, frequently irregular, dark brown or black cross-bars; these covering about one scale length or less, and separated from each other by about three times their own length; bands sometimes very broken posteriorly, remaining evident chiefly as small, middorsal spots.

Specimens examined.—Three, including type.

Range.—Extreme southern Texas to northern Veracruz.

Locality records.—TEXAS: Edinburg (U.S.N.M. no 101051); 3 miles east of Rio Grande City (K.U. no. 4140). VERACRUZ: Tuxpam (U S.N.M. nos. 25201–2).

<div align="center">

TABLE 4.—VARIATION IN FICIMIA STRECKERI

</div>

Number	Sex	Ventrals	Caudals	Supral	Infral	Proo	Ptoo	Intern
25201	♂	144	37	7–7	7–7	1–1	1–1	0–0
25202	♀	149	29	7–7	7–7	1–1	1 1	0–0
101051	♀	143	33	7–7	7–7	1–1	1–1	0–0
4140	♀	144	30	7–7	8–8	1–1	1–1	0–0

Remarks.—The very narrow, dorsal cross bands, separated from each other by a distance about three times their own length, characterize this species and differentiate it from all others The single postocular is also unique In other species the two postoculars may be fused together, or one fused with the supraoculars, but in all such cases the fusion is obvious.

<div align="center">

KEY TO GYALOPION AND FICIMIA

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1. Rostral separated from frontal *Gyalopion* 2
   Rostral in contact with frontal *Ficimia* 4
2. Dark markings on head and middorsum brown, black-edged, head markings variable, not a single large blotch fused with first nuchal spot
   . . . *G. canum*
   Dark markings on head and middorsum uniform black; a large black spot on head, fused with first nuchal spot . . 3
3. Markings restricted to middorsum, not extending onto sides of body; 26 spots on body; no loreal. . . *G. quadrangularis*
   Markings extending onto sides of body to ends of ventrals; 32 spots on body; a loreal . . . *G. desertorum*
4. No dorsal markings whatever; usually two postoculars; usually no internasals . . *F. olivacea*
   Dorsal bands present; one or two postoculars; internasals present or absent 5
5. Dorsal bands very narrow (a scale length or less), separated from each other by about three times their length; one postocular; no internasals
   . . .. *F. streckeri*
   Dorsal bands longer (one and one half or more scale lengths), separated from each other by no more than one and one half times their length; two postoculars usually, internasals present or absent. 6
6. Bands on body 21 to 35; internasals usually present. . . . . *F. publia*
   Bands on body 43 or more; internasals present or absent. 7
7. Internasals present. . . . . *F. ruspator*
   Internasals absent . . .*F. variegata*

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1170TH MEETING

The 1170th meeting was held in the Cosmos Club Auditorium, Saturday, October 12, 1940, President GIBSON presiding.

Program: W. EDWARDS DEMING: *On the sampling problems of the 1940 census.*—This paper was the presentation of a joint study carried out by F. F. Stephan, Morris Hansen, and the author. Properly applied and interpreted, sampling methods are capable of yielding results that for most inquiries are as valuable as those that would be obtained on a complete coverage. Such methods were used to enlarge the scope of the 1940 census. The sample thus obtained contributes in four ways:

I. Since not every person responds to every question, the field work is speeded up and carried out at reduced cost, thus making it possible to carry more questions on the schedule

II. Tabulations can be carried out on the sample for estimates of many population characteristics, months ahead of the regular tabulations prepared from the full count. This is an especially important feature in times of national emergency, and the fact is that several tabulations are even now in progress to obtain quick counts of the distribution of the labor force by area, sex, age, etc.

III. Because the sample tabulations can be carried out at greatly reduced cost, more cross-tabulations can be tabulated and published (i.e., more information made available) than would otherwise be possible.

IV. The sample cards can be stored for subsequent tabulations as the need arises. Storage of the cards for the complete count, even from one decade to another, is not contemplated because of the space required. Storage of the sample cards opens up the possibility, not heretofore realizable, of preserving latent information for several decades.

The sampling scheme puts one person in the sample to represent himself and 19 others. These sample persons were so chosen that the tabulations made up from their characteristics will closely approximate the proportions that would be shown by tabulations made from the entire population. The procedure, so far as the enumerators were concerned, was automatic in its operation. Care was taken to circumvent certain process biases that are inherent in a systematic coverage. The most important process biases arise from the required order of enumeration, by which, in cities, the enumerator starts at a corner and works around the block, and enumerates within each household the head, the wife, oldest child, etc., in a specified order, according to long-established census procedure. The magnitudes of these and other biases were measured by studying the records of previous censuses, in order to see which ones need to be eliminated, and just what the effect is if they are not. The method of designating the sample persons also anticipated and eliminated the effect of a number of enumerators' misunderstandings. (*Author's abstract.*)

The paper was discussed by Messrs. STEPHAN, HANSEN, TRUESDELL, SEEGER, HAWKESWORTH, and SEQUIST.

1171ST MEETING

The 1171st meeting was held in the Cosmos Club Auditorium, Saturday, October 26, 1941, President GIBSON presiding.

Program: E. D. McALISTER, Smithsonian Institution: *Fluorescence and photosynthesis.*--Recent observations of chlorophyll fluorescence show that the intensity of fluorescence depends on the rate of photochemical processes in a living plant. In particular, when the intensity of fluorescence and rate of CO_2 assimilation were recorded simultaneously during the induction period (McALISTER, E. D., and MYERS, JACK, Smithsonian Misc. Coll., 99. No. 6.   1940) it was found that the two curves were nearly perfect mirror images of each other under low oxygen pressures (photosynthesis then being the predominant photochemical reaction) These data suggest the "working hypothesis" that the energy losses from chlorophyll as heat and fluorescence are affected alike by changes in photochemical processes in the plant, i.e., the ratio of heat loss to fluorescence is a constant. If the intensity of fluorescence is plotted against absorbed energy (steady state conditions) a straight line is obtained, under light limitation, the slope of which is proportioned to $(1 - E)$ and E is the upper limit of the efficiency of photosynthesis. (E is the ratio of the number of quanta accepted by the photosynthetic mechanism per second to the number absorbed by the chlorophyll per second.) When photosynthesis is constant or zero a steeper line is obtained, the slope of which is independent of E The ratio of the first slope to the latter is numerically equal to $(1 - E)$. Thus, if the hypothesis previously mentioned is correct, this type of fluorescence data provides a means of measuring an upper limit to the efficiency of photosynthesis.   Particularly significant are the data of Wassink (WASSINK, E. C., et al., Enzymol. 5: 100-109.   1938; 5: 145-172.   1939), wherein, with alga cultured under conditions such as to give high quantum yields, values of E ranging from 0.35 to 0.43 may be calculated from the slopes of his curves for fluorescence with and without poisoning of photosynthesis by cyanide and by urethane. In other words these data may be interpreted to indicate that about half of the energy absorbed by chlorophyll is lost directly as heat *even* under conditions where high quantum yields are obtained (*Author's abstract.*)

JESSE W. M. DuMOND, California Institute of Technology: *The consistency of our knowledge concerning the atomic constants.*—The purpose of this paper was to show in greater detail the construction and use of a certain type of consistency chart already briefly described by the author in a previous paper, and by means of it to exhibit, with a few minor changes and some important new additional data, the present status of the dilemma regarding the values of *e*, *m*, and *h* which grows out of the discrepancy between various results of careful measurements of functions of these variables. The discrepancy itself remains practically as glaring and just as unexplained as ever. Scales have been added permitting the values of *e*, *m*, and *h* corresponding to any intersection point to be read off directly. (*Author's abstract.*)

The first paper was discussed by Messrs HUMPHREYS and ABBOT; the second one by Messrs. ALLISON, BRICKWEDDE, and WENSEL.

1172D MEETING

The 1172d meeting was held in the Cosmos Club Auditorium, Saturday, November 9, 1940, President GIBSON presiding.

Program: E. TELLER: *On the expanding universe.*—The idea that the universe is populated with stars at a roughly uniform density leads to two diffi-

culties which have been recognised for a long time. First, the radiation of distant stars would result in an infinite radiation density at every point, and secondly the gravitational energy due to interaction with distant stars diverges. The fact that the universe expands shows a way out of both these difficulties; moreover, it is not necessary to draw the conclusion that divergences can be avoided only if the total number of stars is finite. The expansion of the universe is proved by red shifts in spectral lines of distant groups of stars, leading to the conclusion that any two such star groups recede with a velocity which is roughly proportional to their distance. Thus one obtains a picture of the system of stars which is somewhat analogous to a crystal in uniform thermal expansion. One may describe such expansion by considering any atom at rest and by saying that the other atoms recede from this atom as a center. The red shift caused by the recession of distant stars lowers the radiation energy received from a distant star all the more the farther the star is, thus making it possible that the total energy arriving at any point remains finite. The gravitational action of distant stars also appears in a new light. Let us consider the gravitational action of the stars within a large sphere on a star located on the surface of that sphere. The gravitational force increases with the size of the sphere, but so does the velocity of the star on the surface with respect to the average velocity within the sphere. The kinetic energy due to this relative motion is under present conditions of expansion much more than sufficient to overcome the gravitational attraction.

Considering the distribution of stars in somewhat greater detail one finds that the stars are grouped in great clusters or galaxies. Within a galaxy the stars are spaced at a few light years apart while the dimension of a galaxy is a few thousand light years. The stars of a galaxy execute motions analogous to the thermal motion of atoms in a gas. The galaxy is held together by gravitational forces and does not expand One finds such galaxies at approximately a million light years apart rather uniformly distributed in space. The galaxies recede from each other so that in our picture of the expanding crystal the galaxies correspond to atoms. It is interesting to notice that the relative velocity of two neighboring galaxies is of the same order of magnitude as the average velocities of stars within one galaxy and also as the thermal velocities of atoms within stars. Extrapolating backward in time to states of the universe where the average density of galaxies has been greater one might be led to the idea that originally all galaxies formed one system, which in separating into star clusters gave rise to similar relative velocities of two resulting clusters as were found for the stars within a cluster. And extrapolating still further back one might suspect that the origin of stellar velocities is the separation of larger accumulations of matter into stars and that during that separation the stars obtained velocities which did not differ greatly from the thermal velocities of the atoms. Thus stellar and also galactic velocities may originate in the thermal motion of atoms which, as has been shown, can in turn be explained by the thermo-nuclear reactions that furnish the energy of the stars. (*Author's abstract.*)

L. B. Tuckerman: *Mathematical spoofing.*—In spite of their traditional reverence for the discipline of logical rigor, even the best of mathematicians at times indulge in spoofing.

This frequently takes the form of devising problems involving some absurdity. Many of these are included in the numerous compilations of mathematical puzzles, and when properly understood are interesting and instructive.

Examples were given of problems that were mathematically correct but

physically absurd, problems that involved mathematical inconsistencies, problems that buried the essential data under a flood of irrelevant words, and problems that were essentially indeterminate.

In the last category are the numerous problems which ask that, from a finite sequence of numbers, the next numbers in the sequence be determined. Several examples were given and their indeterminacy discussed. The logical absurdity of these tests has been pointed out by mathematicians, and mathematicians use them only when they are spoofing. However, in spite of their absurdity they are still included in many of the so-called intelligence tests, to which school children are subjected. (*Author's abstract.*)

The first paper was discussed by Messrs. HAWKESWORTH, MOHLER, BARAFF, and ROLLER; the second one by Messrs. HAWKESWORTH and PAWLING.

1173D MEETING

The 1173d meeting was held in the Cosmos Club Auditorium, Saturday, November 23, 1940, President GIBSON presiding.

Program: H. MARK, Polytechnic Institute of Brooklyn: *Modern aspects of the synthetic rubber problem.*—The production of synthetic products with rubberlike properties is not only interesting from the point of view of National Defense, but it seems to be also promising and timely from the point of view of our present fundamental knowledge on the field of Highpolymeric Substances. The lecture gives a report on the present conception of the structure of such compounds—having long, flexible chainlike molecules—and of the relations between this structure and their technical qualities. (*Author's abstract.*)

This paper was discussed by Messrs McPHERSON, SCHIEFER, and HUMPHREYS.

1174TH MEETING

The 1174th meeting, constituting the 70th annual meeting, was held in the Cosmos Club Auditorium, Saturday, December 7, 1940, President GIBSON presiding.

The treasurer reported that the income from dues and interest on investments was $1,240.45 and that the expenditures exclusive of investments was $994.47, less $10.30 for sale of offprints, leaving a net surplus of $256.28 on ordinary expenses. The ordinary expenses were at the rate of $3.18 per member.

The secretaries' joint report showed an active membership as of December 1, 1940, of 309, of whom the following were elected during the year: C. I. ABLAKSON, JOHN C. BURLEW, PETER A. COLE, TOBIAS DANTZIG, MERRILL DISTAD, ERIC DURAND, FRANK R. ELDRIDGE, R. P. EYEMAN, WALTER E. SCOTT, and IRWIN VIGNESS. The following were elected in 1939 and qualified in 1940: VINTON C. FISHEL and DWIGHT F. WINDENBURG.

The following officers were declared elected for the year 1941:

President, H. E. McCOMB; *Vice-presidents,* W. G. BROMBACHER and R. J. SEEGER; *Recording Secretary,* FRED L. MOHLER; *Treasurer,* W. E. DEMING; *Members-at-Large of the General Committee,* G. E. BENNETT and PAUL A. SMITH.

At the conclusion of the business part of the program Dr. VANNEVAR BUSH, president of the Carnegie Institution of Washington, spoke on *Science in national defense.*

RAYMOND J. SEEGER, *Recording Secretary.*

1175TH MEETING

The 1175th meeting was held in the Cosmos Club Auditorium, Saturday, December 21, 1940, President McComb presiding.

Program: W. J. Eckert, U. S. Naval Observatory: *Scientific computation with the aid of punched cards.*—Scientists faced with extensive calculations have usually used one of three modes of attack: (1) to proceed without delay along the conventional lines, (2) to design a special machine for the purpose, and (3) to adapt to the problem devices made for other purposes. The work described here comes under the third category.

The computing laboratory in the Department of Astronomy at Columbia University employs Electric Punched Card Accounting Machines which have been modified to make them suitable for scientific computation. It was the first laboratory capable of performing general scientific calculation automatically without any reading or writing of figures. In this laboratory many classical astronomical problems, including the numerical integration of the equations of planetary motion, the solution of the main problem of the lunar theory, and the reduction of astronomical observations, have been solved.

The laboratory is now operated for the use of astronomers by the Thomas J. Watson Astronomical Computing Bureau. The bureau is a joint enterprise of the American Astronomical Society, the International Business Machine Corporation, and Columbia University.

Other similar but less complete installations such as the one at the Naval Observatory are now in use. The new Air Almanac was produced in a few months on these machines

Slides were shown to illustrate the basic operation of the machines and their application to the computation of the apparent places of stars. (*Author's abstract.*)

T. B. Brown: *Two-dimensional kinetic theory model.*—The "molecules" of this model consist of ping-pong balls contained in a vertical chamber formed by two glass plates which are separated only far enough to permit free motion of the balls between them. The size of this chamber (18″ wide by 24″ high) is such that the demonstrations may be seen easily by a large audience. A simple agitator-cam, working through a slot in the bottom of the chamber, keeps the balls in a state of rapid random motions.

The apparatus thus demonstrates graphically the motions of molecules as described by the kinetic theory. With the aid of various auxiliary pieces of apparatus, it was used also to illustrate the pressure of a gas against a piston, the diffusion of gas molecules through a porous plug, and Brownian motions of translation, of rotation, and of vibration. The fluctuations from average values which occur in all these phenomena are clearly illustrated and may be studied quantitatively. Such studies serve as useful experiments for the student laboratory. (*Author's abstract*)

The first paper was discussed by Messrs. Maxwell, Garner, McNish, Rappleye, Deming, H. H. Howe, W. Davis, McComb, and Curtis; the second one by Messrs. Brickwedde and Humphreys.

Informal communications were presented by Messrs. Pawling and Rappleye.

1176TH MEETING

The 1176th meeting was held in the Cosmos Club Auditorium, Saturday, January 18, 1941, Vice-president Brombacher presiding.

The Retiring President, Ralph E. Gibson, gave an address entitled *Physical reflections in a chemical mirror.* This address is published in the present issue of the Journal, pp. 325–348.

1177TH MEETING

The 1177th meeting was held in the Cosmos Club Auditorium, Saturday, February 1, 1941, President McComb presiding.

Program: D. R. INGLIS, Johns Hopkins University: *Motions in the earth's core.*—It is well known that the earth is gradually slowing down in its rotation, and that its axis of rotation is gradually changing in a manner that may be approximately described as a "27,000-year precession." Seismological data, while not definite on this point, indicate that the earth's core is probably rather fluid. The fact that the core is made of hot iron and nickel suggests that it is then very fluid. The question treated is whether the inner part of the core keeps up with the rotation of the solid part of the earth, or rotates about some earlier axis of rotation. Calculations based on the existence of turbulent flow in the intermediate layer, and on a drag of magnetic induction, indicate that the axes of rotation of the interior part and of the exterior probably differ in direction by one or several degrees. This involves a rather violent motion of the interior matter relative to the exterior. (*Author's abstract.*)

This paper was discussed by Messrs. HERZFELD and HAWKESWORTH.

A. B FOCKE, Brown University: *Segregation of polonium in bismuth crystals.*—Single crystals of bismuth containing polonium as an impurity were studied to determine the distribution of the polonium. Number-distance relations for α-particles emitted normally through cleavage surfaces afford the means of investigation, measurements being made with a Geiger-point counter. When present in very small concentrations polonium is found to be segregated into small regions which have nearly regular spacing when viewed in several directions. These average spacings, 0.55 micron for planes parallel to the (111) plane and 0.86 micron for planes parallel to the (1̄11) plane, are not affected by the speed of growth of bismuth crystals or by subsequent heat treatment. In the case of mechanical twinning, it is found that the spacing between polonium groups follows the crystallographic changes. (*Author's abstract.*)

1178TH MEETING

The 1178th meeting was held in the Cosmos Club Auditorium, Saturday, February 15, 1941, President McComb presiding.

Program: C. A. BETTS, U. S. Forest Service: *Heavy construction.*—The great variety of interesting problems encountered in heavy construction was illustrated by the following projects on which the speaker has been engaged; The six-mile Moffat Tunnel in Colorado; the $3\frac{1}{2}$ and $4\frac{1}{2}$ mile Owyhee water tunnels in Oregon, and the Owyhee Dam (the highest prior to the Boulder Dam), and smaller dams. Construction problems of the National Forest Service, including bridges, roads and fire lookout towers, were also described and illustrated. (*Abstract by the Secretary*)

E. S. GILFILLAN, Consulting Engineer: *What happens when candy burns.*—It was shown that for the group of reactions of one chemical element with another there exists a critical series, analogous to the sum-of-states familiar in statistical mechanics, having the property that at temperatures for which the series converges the compounds break into clean fragments whereas for temperatures for which the series diverges very complex products are formed as equilibrium is approached. It is thus that charring and tar formation occur. For most pairs of elements, the temperatures of divergence are so low that no perceptible reaction would be expected to occur even in intervals long in geologic time. In the case of carbon and hydrogen, however, at the

partial pressures of hydrogen which obtain in equilibrium with mixtures of iron, iron oxides, carbon, and water vapor, the critical series diverges at temperatures at which fairly rapid reaction of these elemnts is known to occur. It was suggested that petroleum may have been formed in this way. (*Author's abstract.*)

An informal communication on *Resistivity of interstellar space* was presented by F. L. MOHLER.—It was pointed out that on the basis of recent estimates of conditions in interstellar space, the equation for resistivity of an ionized gas is applicable and the resistivity is about 0.2 ohms per cm cube. Thus interstellar space is a highly conducting medium. (*Author's abstract*) This was discussed by Messrs. HUMPHREYS, GILFILLAN, and BRICKWEDDE.

1179TH MEETING

The 1179th meeting was a joint meeting with the Washington Academy of Sciences. Prof. P. W. BRIDGMAN, of Harvard University, delivered an address entitled *The changing position of thermodynamics.*

1180TH MEETING

The 1180th meeting was held in the Cosmos Club Auditorium, Saturday, March 1, 1941, President McCOMB presiding.

Program: F. O. RICE, Catholic University of America. *Mechanism of chemical reactions.*—The chemist represents the reactions that he studies by equations such as,

$$C_8H_{18}+17O_2 \rightarrow 8CO_2+9H_2O,$$
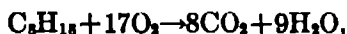
which represents the combustion of octane, or

$$2Na_2SO_3+O_2 \rightarrow 2Na_2SO_4,$$

which represents the oxidation of sodium sulphite to sodium sulphate and occurs readily at room temperature in aqueous solution. The decomposition of acetone is represented by the equation,

$$CH_3COCH_3 \rightarrow CH_4+CH_2=CO$$

which shows the formation of methane and ketene; however this occurs only at about 500°C. or higher.

All these reactions have one peculiarity in common, namely that the rate of the reaction can be profoundly influenced by the addition of relatively minute amounts of other substances. The puzzling feature is that by selecting an appropriate substance, these and many other reactions can be slowed up so that the rate can not be measured.

The present day explanation of this curious effect is that these reactions consist really of a complex series of steps in which a free radical generated initially causes a cycle of reactions in which it (or some other radical) is regenerated in each cycle and can therefore start the next cycle. It is, therefore, reasonable to expect that a substance which can combine with or destroy radicals will reduce the rate of such a reaction even if the substance is present in very small amounts. (*Author's abstract.*)

K. F. HERZFELD: *Propagation of sound in liquids.*—In liquids as in gases, sound waves consist in alternate compressions and attenuations, accompanied by temperature variations. For the same energy radiated, the pressure variation is much higher, the temperature variation lower in the liquid than in the gas.

Absorption of sound in liquids has been measured reliably up to about 80 megacycles in mercury, water, and three other liquids and turns out to be proportional to the square of the frequency. Except for mercury, it is several times larger than can be accounted for by viscosity and heat conduction. Attempts to explain this increased absorption by slowness of energy exchange between internal and external degrees of freedom seem successful for benzene, but not for water.

In liquid mixture, sound waves should produce partial unmixing, but the effect is too small to be observable. (*Author's abstract.*)

The first paper was discussed by Messrs. HUMPHREYS, CURTIS, BRICKWEDDE, HAWKESWORTH, and GIBSON; the second one by Messrs. GILFILLAN, ROCK, GIBSON, and BRICKWEDDE.

1181ST MEETING

The 1181st meeting was held in the Cosmos Club Auditorium, Saturday, March 15, 1941, President McCOMB presiding.

Program: S. L. QUIMBY, Columbia University: *Investigations with the piezoelectric oscillator.*—The composite piezoelectric oscillator is a device which permits the measurement of the elastic constants and internal friction of single and polycrystalline solids. A small right circular cylinder of specimen material is cemented at one end to a suitably cut crystalline quartz cylinder of identical cross section. The quartz cylinder carries electrodes properly oriented with respect to the electric axes of the crystal, and a harmonically varying potential difference is maintained between these electrodes. In consequence of the harmonically varying piezoelectric stress which accompanies the electric field in the quartz, a state of forced longitudinal or torsional vibration is established in the composite system which, under these circumstances, is electrically equivalent to a series resonant circuit shunted by a capacity. The fundamental frequency of free longitudinal or torsional vibration of the composite system and the vibration decrement are deduced from the observed variation of the reactance of this circuit with frequency, and its resistance. These data, in combination with the results of corresponding measurements made on the quartz cylinder alone, yield values of the elastic constants and coefficients of internal friction of the specimen material. Particular advantages of the method are its high accuracy, economy of specimen material, and the ease with which measurements can be made at very low temperatures.

The method has been used to measure the variation of the principal elastic constants of NaCl, KCl and MgO with temperature at low temperatures, and of NH_4Cl, β-brass, and the copper-gold alloys through their transition temperatures; also, the variation of the elastic constants and internal friction of iron and permalloy with magnetization, and of nickel with magnetization and temperature through the Curie point. It has recently been extended to the treatment of non-homogeneous specimens, and studies have been made of the phenomenon of plasticity in single metal crystals. (*Author's abstract.*)

ALEXANDER HOLLAENDER, National Institute of Health: *The wavelength dependence of genetical changes produced by ultraviolet radiation.*—The results of the studies on the genetical effects of monochromatic ultraviolet radiation between 2180 and 3650A on typical fungous spores were discussed on the basis of work done in cooperation with Dr. C. W. Emmons. The technique used insured that on the average each spore received and absorbed definite quantities of energy. Survival ratios were determined from plate counts for

the different wavelengths tested. Three different types of effects were observed: (1) Toxic or fungicidal effect; (2) physiological changes, and (3) genetical changes. Fungicidal and genetical effects show a maximum of sensitivity in the wavelength range around 2600A. This wavelength is most highly absorbed by nucleic acids which are one of the main constituents of chromosomes. Genetical effects of monochromatic ultraviolet radiation have also been observed after the irradiation of liverwort sperm, pollen grain of maize, and *Drosophila* sperm. The wavelength dependence of mutation production in Drosophila is complicated by the fact that the sperm has to be irradiated with our present technique inside the living animal, and the injurious effect of ultraviolet radiation obscured the results. The significance of these findings was discussed in relation to the possible role of sunlight on the production of natural mutations. (*Author's abstract.*)

The first paper was discussed by Messrs. BARAFF, SEEGER, GOLDBERG, and TUCKERMAN; the second one by Messrs. BARAFF, McCOMB, and MOHLER.

1182D MEETING

The 1182d meeting was held in the Cosmos Club Auditorium, Saturday, March 29, 1941, President McCOMB presiding.

The Eleventh Joseph Henry Lecture, entitled *The constitution of diffuse matter in interstellar space*, was delivered by OTTO STRUVE, professor of astronomy at the University of Chicago. This lecture has been published in this JOURNAL 31: 217-258. 1941.

1183D MEETING

The 1183d meeting was held in the Cosmos Club Auditorium, Saturday, April 12, 1941, President McCOMB presiding.

Program: TOBIAS DANTZIG: *Mathematics; prospects and retrospects.*—The period through which we are now passing would be replete with tricentennial celebrations and jubilees if the world were in a mood for jubilees. Three hundred years ago modern science generally, and mathematics in particular, had come of age: the two decades from 1630 to 1650 saw the births of such important mathematical disciplines as Analytic and Projective Geometry, Infinitesimal Analysis, Theory of Equations and Theory of Numbers, Analytical Mechanics, and the Theory of Probabilities. The speaker reviewed that period, the problems which confronted it, the characters and the attitudes of the great men who launched the new sciences against the social, economic, and political backgrounds of those turbulent times, when human thought had just emerged from the oppressive influence of Scholasticism and reliance on authority. He then undertook to draw a parallel between that period and the critical times through which we are now passing. The events of the last three decades have forced upon thinking men everywhere a revaluation of values, and mathematics is no exception to this trend. The foundations of the mathematical sciences have undergone a searching critique, which few of the concepts and axioms on which these sciences rested survived unscathed. But there is also another tendency. Mathematics is an art, and as such it has not been spared the disease which has afflicted modern music, art and literature: the substitution of form for content, which was so characteristic of the Dark Ages. Whether this is but a passing malady, or augurs a decadence and a relapse into medievalism, time alone will show. However, the speaker saw definite symptoms of a healthy revolt against this sterile formalism. (*Author's abstract.*)

ARNOLD H. SCOTT: *A mechanical aid for selecting the essential terms of a determinant.*—It was shown that the method of expanding determinants whereby the rows are interchanged so that the terms of the expansion appear successively in the principal diagonal can be of material assistance in picking out wanted terms in special determinants. The determinant used for illustration was one in which all the elements of the principal diagonal had the value X except one and more than a third of the other elements were zero. The terms required in this particular problem were those containing the three highest powers of X. The rows were printed on strips of cardboard which allowed a ready interchange of the rows. Only those row interchanges were required which removed one or two X's from the principal diagonal. The terms of the expansion were then obtained from the principal diagonal in a progressive series order. (*Author's abstract.*)

The first paper was discussed by Messrs. BLAKE and SEEGER; the second one by Messrs. HAWKESWORTH, TUCKERMAN, DANTZIG, and CURTIS.

1184TH MEETING

The 1184th meeting was held in the Cosmos Club Auditorium, Saturday April 26, 1941, President McComb presiding.

Program: ROBERT B. BRODE, University of California: *Cosmic-ray ionization.*—The cosmic radiation produces most of its effects at the earth's surface by the ionization along the paths of high energy charged particles. This ionization is observed by means of ionization chambers, Geiger counters, and Wilson cloud chambers. Most of the vertical coincidence counts in a pair of Geiger counters appear to be due to mesotrons. A study of the ionization along the paths of mesotrons and along the paths of electrons enables the relative mass of the particles to be estimated. The specific ionization or the total ionization produced per centimeter of the path can be obtained from cloud chamber measurements. Pictures are taken of the track after a delay of 0.1 sec. which permits the ions to diffuse slightly. With high resolution photography the individual water drops can then be counted. Each of these drops has an ion as a nucleus. Positive and negative ions can be distinguished by their motion in the clearing field or by their behavior under different expansion ratios of the cloud chamber. Electrons with an energy of a million electric volts energy have an ionization of about 45 ions pairs per cm of path. Both faster and slower electrons have greater ionization. This experimental observation agrees with the predictions of Bohr and others. Mesotrons of two hundred times the mass of an electron and with an energy of one hundred million electron volts would be expected to have about the same ionization as one million volt electrons. (*Author's abstract.*)

J. E. MAYER, Columbia University: *Statistical mechanics and liquids.*—The general methods of statistical mechanics have not been greatly changed since the time of Gibbs, although the introduction of quantum mechanics has altered many details and improved the agreement with experiment.

The general equations can be solved in only two cases, that of the gas and that of the crystal. The problem is essentially that of integration over the coordinates of some 10^{23} particles of an integrand which is the exponential of minus the potential energy of the system, divided by kT. This integration is practical only if the result can be expressed as a product of integrals over fewer coordinates. In the case of the gas, this is done by expanding the integrand into terms, the first of which is unity and gives the value of the integrand when all particles are far apart. The following terms give the corrections due to clusters of molecules which are close to each other.

In the case of the crystal, the problem is solved by assuming a configuration of minimum potential energy and expanding the integrand over very small deviations from this equilibrium position. In this case the integral becomes the product of the integrals over the so-called normal coordinates.

Neither of these two methods can be expected to work for a system at the temperature and density of a liquid. It is then necessary to find some other method of solution. One developed by Kirkwood and an analogous one developed by Mayer and Montroll appears to offer some hope. In this method one starts in the middle of the problem and works towards both ends Distribution functions giving the probabilities of certain configurations for a small number of molecules, are introduced. The thermodynamics properties of the system can be calculated in terms of these distribution functions. By a method of successive approximations, it appears that the distribution functions themselves can be determined. (*Author's abstract*)

The first paper was discussed by Messrs. MOHLER, P. A. SMITH, BARAFF, MAYER, BRICKWEDDE, and McCOMB, the second one by Messrs. HAWKESWORTH, HERZFELD, and BRODE.

1185TH MEETING

The 1185th meeting was held in the Cosmos Club Auditorium, Saturday, May 10, 1941, President McCOMB presiding.

Program: R. M. BOZORTH, Bell Telephone Laboratories: *The physical basis of ferromagnetism.*— After an introductory review of the general nature of magnetic phenomena and the magnitudes of the atomic forces involved, there was a discussion of the atomic structure of the ferromagnetic elements and elements having similar structures This included a description of the gyromagnetic experiments and their interpretation and of atomic energy levels and exchange interaction. The properties of single crystals and the structure of domains were described in relation to the form of the magnetization curve and the nature of magnetic processes accompanying changes in field-strength. Two simple demonstrations were made of the Barkhausen effect and the directional magnetic properties of crystals. (*Author's abstract.*)

This paper was discussed by Messrs. ROLLER, BATES, KRACEK, HUMPHREYS, DORSEY, JOYCE, McCOMB, PINEO, and McNISH

An informal communication was presented by PAUL R. HEYL on a law of falling bodies proposed by Galileo in *Two new sciences.* Galileo assumed that the velocity was proportional to the distance fallen and the consequences of this were discussed. This was discussed by Messrs McNISH and HUMPHREYS.

1186TH MEETING

The 1186th meeting was held in the Cosmos Club Auditorium, Saturday, May 24, 1941, President McCOMB presiding.

Program: C. L. GARNER: *Recent developments in geodetic control.*—This paper consists of a brief outline of the status of the geodetic control work, particularly triangulation, in the United States at the present time, and its relation to mapping and other engineering and scientific works of national importance. It reviews very briefly the extension of the horizontal control net of the United States from its inception in 1817 to the present, showing that by far the larger part of the work as it stands today has been accomplished during the last decade. This was through the use of emergency funds for the relief of unemployment and at one time involved the employment of more than 10,000 people distributed in all of the states in carrying on ex-

tremely important work in vital areas. There is also sketched in brief the present methods of procedure in the operation of a triangulation party using steel towers, automobile trucks, and modern instruments of various types. Problems encountered in the field in carrying on the work with the required accuracy and the resulting field work are discussed in detail. (*Author's abstract.*)

HOWARD S. RAPPLEYE, *Problems in vertical control surveys.*—This paper first outlined briefly the fundamental equipment and process of spirit leveling, continued with a brief description of the precise leveling equipment and procedure of the U. S. Coast and Geodetic Survey and discussed the extent of the vertical control net. Emphasis was placed on the difficulties and problems involved in the field and office work preliminary to the publication of the final results in the form of lists of descriptions and elevations of bench marks.

The latter part of the paper discussed the difficulty of maintaining the bench marks in the field with special reference to problems involved in preventing destruction of bench marks as a result of construction, repair and maintenance activities; natural causes, such as frost heaving, rock disintegration, etc. The effect of earthquakes, regional settlement and other causes of the disturbance of bench marks were also covered briefly. (*Author's abstract.*)

The first paper was discussed by Messrs. MAXWELL, BROMBACHER, TUCKERMAN, and SMITH; the second one by Messrs. SMITH, HECK, BLAKE, H. L. CURTIS, TUCKERMAN, and McCOMB.

FRED L. MOHLER, *Recording Secretary.*

ENTOMOLOGY.—*Notes on the American representatives of the butterfly genus* Argynnis.[1] AUSTIN H. CLARK, U. S. National Museum.

The problem of the interrelationships of the numerous forms of the genus *Argynnis* occurring in North America is an interesting one. In sharp contrast to the various species of Europe and Asia, we find among the American species extraordinary similarity in fundamental characters of structure and in color pattern, combined with an equally extraordinary diversity in details. Characteristic of all the American argynnids, with the exception of *A. diana*, are the arrangement and relative size of the spots on the under side of the hind wings, although they may or may not be silvered, and the ground color of the wings may be green or brown of various shades, yellow, or even deep purple, uniform or more or less mottled or variegated with lighter or darker, from sharply to only vaguely contrasting with the spots, and with or without a broad or narrow light marginal band. Especially noteworthy in the American argynnids is the entire absence on the under side of the hind wings of the submarginal row of eye spots, which, more or less developed, occurs in very nearly all the Old World species no matter how much the rest of the color pattern may differ. These eye spots, sometimes reduced to dots, are equally characteristic of the species of the genus *Brenthis* and are present in all the American forms in that group.

The only European and Asiatic species of *Argynnis* that lack all traces of these eye spots are *aglaia*, *elisa*, *clara*, and *alexandra*. In *aglaia* not only are these spots lacking, but the color pattern above and below resembles that characteristic of the American forms. On the under side of the hind wings the spots are of the same shapes and proportions as the corresponding spots in the American forms, and the light band between the marginal and inner rows of spots found in nearly all the American forms is present in most of the numerous races.

Argynnis aglaia ranges from the British Isles and most of Europe and Asia Minor eastward throughout Asia as far south as Kashmir and northwestern India to eastern Asia and Japan. It is divisible into a number of local races or subspecies that differ considerably in size and in color, especially in the ground color of the under side of the hind wings. Wherever this butterfly occurs it is abundant, or at least common.

Under the name of *washingtonia* Drs. Barnes and McDunnough have described a form from British Columbia and Washington that does not seem to differ in any tangible character from *A. aglaia* as it occurs in eastern Asia. There is an average difference in specimens from the two regions, but in all characters they appear to intergrade. The American specimens may usually be distinguished by the presence of a silver dash on the under side of the hind wings near the narrowly silvered abdominal border about halfway from the base to the anal angle. This silver dash is typically absent in Asiatic specimens, but traces of it occur in some from Si-Gong-Kong, near Tatsien-Lu, and from Tang-Gu, and in one at hand from Tang-Gu it is well developed.

There can be no doubt that *washingtonia* is simply an American representative of the European and Asiatic *A. aglaia*, and that it should be included in our lists as *Argynnis aglaia washingtonia*. Here, however, we encounter one of those conflicts between systematic zoology and taxonomy that tend to obscure a true appreciation of the interrelationships of animal types. In Dr. McDunnough's latest list *washingtonia* is given as one of the six subspecies of *A. eurynome* Edwards, the other five being *eurynome, bischoffi, opis, artonis,* and *luski.* Now although *eurynome* was the first of these to be described, *washingtonia,* not specifically distinct from the Old World *aglaia,* is undoubtedly the basic form from which the others were locally derived, if it is assumed that these six forms are really subspecifically related.

It appears reasonable to consider that, in spite of their diversity, they are closely related. Their interrelationships are, however, of a nature quite different from those between *aglaia* and its European and Asiatic subspecies. They involve curious and unusual factors such as the paling of the under side of the hind wings in *artonis,* which reaches an extreme and is combined with partial obliteration of the spots in *opis,* and a paling of the ground color to a light dull yellow on which the position and shape of the spots is indicated by narrow dark outlines in *luski.* It would appear possible to regard

these strange variants from the *aglaia–washingtonia* type as forms that have arisen by mutation quite independently of their immediate surroundings and have become locally established either in the same area as the stem form or in different areas, rather than as the usual type of subspecies which is a modification, by mutation or otherwise, of a specific type in more or less definite, or at least assumed, response to local ecological conditions.

If this hypothesis be acceptable it can be expanded and broadened to cover all the American argynnids, which would then be interpreted as fundamentally mutants from the highly plastic *aglaia* stock. Some of these mutants, as *A. cybele*, *A. aphrodite*, and *A. atlantis*, are stable entities and, ranging widely, have developed local races or subspecies of the usual type. Others, in the Southwest and Southeast at the maximum distance from the territory inhabited by *A. aglaia washingtonia*, are highly aberrant, like *A. caerulescens* and *A. diana*, which, except in color, do not differ essentially from *A. cybele*, and *A. idalia*.

With wide departures from the normal in color are associated curious ecological characteristics. Both *Argynnis diana* and *A. idalia* have a very wide range within which neither shows any noticeable tendency to form local races. *Argynnis diana* is strictly a woodland form occurring only in warm regions but always near cold water, either cold mountain streams or extensive cold seepages as along the western border of the Dismal Swamp. On the other hand, *A. idalia* is confined to open grass lands, moist meadows in the lowlands and open pastures in the southeastern mountains.

The interpretation of our American argynnids as primarily derivatives, mostly by more or less abrupt mutation, from *aglaia* stock represented in North America by *washingtonia* would explain the close similarity in the fundamental features upon which is superimposed extraordinary diversity in detail. It would also explain the curiously involved character of their interrelationships which makes it practically impossible to arrange them in any logical and convincing systematic pattern.

Among the species of the related genus *Brenthis* there are certain points that should be brought out.

The common North American species known as *myrina*, including the several recognized subspecies, is, taken as a whole, indistinguishable from the widespread and variable *selene* of Europe and Asia. The most constant difference between the Old World forms grouped under the name of *selene* and the American forms collectively considered as *myrina* is found in the black central dot in the spot occupy-

ing the greater part of the cell on the under side of the hind wing. In *selene* this dot is large and is typically not ringed with lighter. In *myrina* it is small and is ringed more or less completely with silver or with light yellow. But even this character is undependable. A specimen of *selene* at hand from Rennes, France, in this as in other features is almost an exact duplicate of another from Tolland, Colo., and if the place of origin were unknown it would certainly be referred to the form *tollandensis*. A specimen from Hopedale, Labrador, is very close to others from northern Europe and perhaps should be referred to the same subspecies.

The North American forms now grouped under *Brenthis myrina* should be listed as:

Brenthis selene myrina (Cramer)
Brenthis selene atrocostalis Huard
Brenthis selene terrae-novae Holland
Brenthis selene nebraskensis Holland
Brenthis selene tollandensis Barnes and Benjamin
Brenthis selene marilandica, subsp nov

Brenthis selene marilandica, subsp. nov.

Diagnosis - Resembling *Brenthis selene myrina* but larger, the fore wings 22–25 (averaging 23 75) mm in length, and with the ground color above darker and more reddish and the black markings broader and heavier, often much heavier so that they are more or less extensively confluent; on the under surface the color varies from about as dark as in the darkest *myrina* (from Massachusetts) to very appreciably richer, with the black markings on the under side of the fore wings always heavier.

Type —From the boggy pasture on the south side of the road from the Beltsville, Md , railway station to the Department of Agriculture experiment farm, collected by Austin H Clark on July 6, 1929 (U.S.N.M. no. 55470, figured in U. S. Nat Mus. Bull 157, pl. 3, figs. 5, 6, 1932).

Remarks —This form has only a single brood, flying from the end of June (earliest date June 29) to about the end of July. In the past it was rather common in the type locality, but it has not been found in recent years. No other locality for it is known. The common form of this species in Maryland and in western Virginia is *myrina*

ENTOMOLOGY.- -*Five new Guatemalan scarab beetles of the genus Phyllophaga.*[1] LAWRENCE W. SAYLOR, U. S. Fish and Wildlife Service.

Opportunity is taken herewith to characterize five new species of Scarabaeidae from Guatemala. All belong to the genus *Phyllophaga* Harris (subgenus *Phyllophaga*), and the holotypes of all are in the author's collection.

[1] Received May 13, 1941.

Phyllophaga (Phyllophaga) duenas, n. sp.

Male.—Oblong-ovate, slightly wider behind; color rufocastaneous, faintly pruinose above; dorsal surface griseopilose. Clypeus moderately long, the apex truncate, entire, and slightly reflexed, with the angles broadly rounded; disk very densely and coarsely punctate. Front coarsely scabrose, with long erect hairs. Antennae 10-segmented, rufotestaceous; club ovate, equal in length to segments 3–7 combined. Thorax with sides dilated, ciliate, hardly crenulate, straight before the dilation and slightly sinuate behind; front angles subrectangular, hind angles obtuse; disk with very dense and fine punctures, each separated by about its own diameter, those in apical half and at sides faintly scabrose and very slightly larger, all discal punctures with short, suberect, griseous pile and a few slightly longer hairs near center apex. Elytra ecostate, sutural costa not well defined; disk with the fine, dense punctures separated by once their diameters, and all with short, suberect, griseous hairs, with a few longer hairs near base of disk. Pygidium slightly convex, pruinose, and punctured like the elytra, with very short suberect hairs mixed with short erect hairs, apex reflexed and slightly thickened. Abdomen pruinose, flattened, slightly longitudinally impressed, surface very finely and densely punctate, with short procumbent hairs; fifth sternite faintly, lobately produced at midapical margin, disk flat and with a dense median patch of small granules and short hairs; sixth sternite half the length of fifth, the basal margin thickened and carinate with the middle base lobately reflexed toward the apical margin and the apex of this lobe forming a somewhat broad transverse carina that is slightly tumid at each end; apical margin carinate, though narrowly interrupted at the middle, and ciliate; disk densely and finely punctate, with long erect hairs. First segment of hind tarsus shorter than second, spurs free. Claws with basal tooth submedian in position and a little broader and longer than apical tooth, also faintly reflexed toward the base; claw base broad and very obtusely dilated. Length 16.5 mm.

The unique male holotype, in the Saylor collection, is from "Duenas, Guatemala." The species is related to *P. abdominalis* Moser, but the sixth abdominal sternite is quite different and the abdomen is slightly impressed.

Phyllophaga (Phyllophaga) nepida, n. sp.

Male.—Robust-oval, wider behind; color piceocastaneous, thorax dull and faintly pruinose, dorsal surface haired. Clypeus short, transverse, and nearly rounded, the apex entire and slightly reflexed, the angles hardly indicated; disk densely, coarsely, and setigerously punctate. Front densely and coarsely punctured, with short erect hairs. Thorax with sides slightly dilated, ciliate, entire, and subparallel behind, angles obtuse but well indicated, disk evenly punctate, with moderately coarse, dense, variolate punctures, each separated by more than once its diameter on disk, though closer at sides, and each with a short suberect hair; front margin with long cilia. Elytra, except for the sutural rib, ecostate; disk densely punctured, as thorax, with short, suberect, griseous pile and a few longer intercalated hairs on suture and near base. Pygidium slightly convex, polished, basal half pruinose; disk densely and coarsely punctate, with short erect hairs of two lengths; apex truncate and ciliate. Abdomen pruinose, flattened, and faintly longitudinally sulcate at middle; fifth sternite declivous at apex, with a large patch of granules at middle and short erect hair; sixth nearly as long as fifth, transversely flattened and subgranulately punctate, with a faint, smooth, longitudinal impression; the basal margin somewhat thickened and subcarinate, though interrupted at middle. First segment of hind tarsus shorter than second;

spurs free. Claws short, robust, basal tooth short and triangular and slightly basad of middle, the base hardly dilated. Genitalia of the bilaterally symmetrical, complete, ring-shaped type; in *en-face* view the lateral angles are moderately long, very sharp, and somewhat convergent toward the center, the center underpiece well indicated and divided into two sharp, subparallel, slender teeth.

Female.—Antennal club ovate and equal in length to segments 3–7 combined; the front thoracic angles rectangular and the hind angles nearly so; elytra with very sparse longer hairs all over the surface, those at base somewhat thicker than corresponding hairs of the male; pygidium more flattened and a little more coarsely punctate in apical half; abdomen flattened, the fifth and sixth sternites plane and densely and setigerously punctate; otherwise similar to male. Length 14–15 mm.

The holotype male, allotype female, and paratype female, which remain in the Saylor collection, are from "Finca San Juan, Alta Vera Paz, Guatemala." They were collected by Felix A. Muenchmeyer. This species is near *P. wittkugeli* Nonfried but differs in the male genitalia and the dorsal sculpture.

Phyllophaga (Phyllophaga) ferupilis, n. sp.

Male.—Elongate-subparallel; color rufocastaneous and slightly shining, above entirely griseopilose. Clypeus long, flat, nearly trapezoidal, the apex subtruncate and entire, the angles narrowly rounded; disk very coarsely and densely punctate, with erect hairs. Front coarsely and contiguously punctate, with short erect pile. Antennae 10-segmented, rufous; club very long, subequal in length to the entire stem; segments 5–7 with short spines on the inner apical margin. Thorax, elytra, and pygidium with extremely fine and extremely dense punctures over the entire surface, with short procumbent hairs; on the elytra adjoining the scutellum there are several longer hairs, which, however, are still rather fine. Thorax with the sides dilated in front of middle, ciliate, entire in front and crenate behind the dilation, angles obtuse but angulate. Elytra with a strong membranous margin, the sutural costa weakly indicated; sutural costae hardly obvious at base and apex. Pygidium faintly convex, its apex subrounded and reflexed. Abdomen punctured and haired like the elytra, its center flat; fifth sternite very slightly prolonged at middle of the apical margin into a small lobe, disk with a dense patch of fine granules; sixth sternite half the length of fifth, transversely sulcate and punctate, basal margin much thickened and subcarinate, especially at the middle, where there is a very small, triangular, apical gibbosity, which is impressed at center and slightly granulate each side; apical margin of sixth sternite carinate and ciliate and interrupted at the middle. First two hind tarsal segments subequal, the spurs free and very graceful. Claws with a sharp basal tooth, which is median in position and of nearly same size and length as apical tooth; claw base angularly dilated but obtuse. Genitalia bilaterally symmetrical; in lateral view the lateral margins are greatly rounded and overhang the small and bidentate median underpiece. Length 24.5 mm.

The unique male holotype, in the Saylor collection, was collected by Felix A. Muenchmeyer at "Finca San Juan, Alta Vera Paz, Guatemala." The species is near *P. ferrugata* Moser but is much larger, and the abdominal characters are distinct.

Phyllophaga (Phyllophaga) totonis, n. sp.

Male.—Oblong-ovate; color castaneous, shining, head and thorax piceocastaneous; hairy above. Clypeus moderately long, apex hardly reflexed,

very narrowly but distinctly emarginate, the angles very broadly rounded, disk with coarse, dense, setigerous punctures. Front very densely, coarsely, and scabrosely punctate, with very long brownish hair. Antenna 10-segmented, rufobrunneous; club long, about one-fourth longer than funicle but hardly as long as the entire stem. Thorax with sides strongly dilated, with long cilia, straight before dilation and noticeably sinuate behind it, the margins subcrenate; front angles obtuse, hind angles distinctly rectangular; disk with dense, moderately coarse, umbilicate punctures, each separated by once its diameter, or slightly more, somewhat closer at sides, all punctures with very long erect hairs and without intercalated shorter hairs; an area of disk at each lateral dilation, and along base each side of the middle to the hind angles, smooth and impunctate. Scutellum impunctate. Elytra with sutural stria strong and with a moderately indicated, oblique first discal stria, which becomes progressively wider toward the apex, where it is evanescent; disk rugose, punctures small, irregularly and not densely placed, with very long hair near scutellum and along lateral margins, the disk with a few short, scattered hairs. Pygidium convex, polished; disk rugose, the punctures very fine and dense and with fine erect hair of short to moderate length; apex widely subrounded. Abdomen flattened, highly polished, middle glabrous and very finely and sparsely punctate; fifth sternite somewhat declivous behind, basal fourth smooth, apical portion with a small patch of fine dense punctures; sixth sternite faintly longer than fifth, widely shallowly foveate, the disk densely and finely subgranulate and punctate at sides with long erect hairs. First segment of hind tarsus a little shorter than second. Claw widely cleft, the upper tooth nearly twice as broad as apical and apex obliquely truncate; both teeth of approximately the same length; claw base distinctly though obtusely dilated. Genitalia bilaterally symmetrical, the lateral lobes free at apex though touching; in *en-face* view the lateral lobes have each a short thumblike lobe at the middle projecting upward, and at the lower apex each lateral lobe is very broad and the apex is emarginate, the two blunt inner lobes touching or slightly overlapping at the center. Length 13.5 mm.

The unique male holotype, in the Saylor collection, is from "Quicke Totonicapan, Guatemala, May." The species is near *Phytalus xanthocomus* Bates but differs in the pygidial characters and antennal length. From *P. castaneipennis* Moser, *totonis* differs in the clypeal form and in the elytral characters.

Phyllophaga (Phyllophaga) mentalis, n. sp.

Male.—Oblong-oval, widest behind; color rufotestaceous and strongly shining, head and thorax rufous; very nearly glabrous above. Clypeus flat and very broad; apex slightly reflexed and very narrowly sinuate at middle; the angles very broadly rounded; disk with somewhat coarse, moderately dense, irregularly placed punctures. Front sparsely punctate like the clypeus, with very sparse, short, erect hairs near sides. Vertex impunctate. Antenna 10-segmented, rufotestaceous; club ovate and minute, scarcely equal in length to segments 5–7 combined. Thorax with sides arcuate, nearly entire, and slightly ciliate, the angles rounded; base not margined at middle; front margin thickened and slightly sinuate; disk with somewhat coarse, moderately dense punctures, which are slightly less dense at center. Scutellum punctate. Elytra with two discal striae, other than sutural, weakly indicated; disk punctured as thorax but a little more densely and more irregularly so. Pygidium polished, slightly convex, glabrous, disk punctured like the thorax, the punctures a little finer. Abdomen convex, highly polished, and very finely not densely punctate at middle, with a few short scattered

hairs; fifth sternite no different from third and fourth; sixth sternite three-fifths the length of fifth and widely transversely impressed, the apex and base slightly thickened, carinate, and not interrupted, except very narrowly at apex; disk of sixth sternite wrinkled and not obviously punctate, apparently glabrous and with a very fine longitudinal sulcus. First segment of hind tarsus slightly shorter than second; spurs free. Claw very short and robust, the basal tooth very small, short, and strongly inclined toward, but narrowly separated from, the weakly dilated claw base. Mid and hind tibiae each with several small serrations on the outer margin. Labrum large, very deeply and narrowly cleft to base. Mentum very deeply and longitudinally sulcate. Length 19 mm.

The unique male holotype, in the Saylor collection, is from "Trece Aquas, Cacoa, Guatemala." The species appears to be quite different from any known to me in a number of characters but somewhat approaches *P. parvicornis* Moser, from which it may be separated by the different abdominal structure, densely punctate pygidium, and punctate scutellum.

ZOOLOGY.—*Notes on Mexican snakes of the genus* Masticophis.[1] Hobart M. Smith, Smithsonian Institution. (Communicated by Herbert Friedmann.)

The following notes are based on the Mexican whipsnakes in the U. S. National Museum (to which specimen numbers refer, unless otherwise indicated), and on a portion of the E. H. Taylor-H. M. Smith Mexican collection. I am much indebted to Dr. E. H. Taylor for loan of material and other courtesies too numerous to mention. A portion of the specimens were collected during my tenure of a Walter Rathbone Bacon Traveling Scholarship, of the Smithsonian Institution.

Masticophis mentovarius (Duméril and Bibron)

Eleven Mexican specimens are from the following localities: CHIAPAS: Tonalá (no. 111270), near Colonia Soconusco (no. 111269). OAXACA: Juchitán (no. 30231); Tehuantepec (nos. 30422-3, 111274-6); Cerro de Huamelula (no. 111272); Mixtequilla (no. 111271); Cerro Arenal (no. 111273). One in the EHT-HMS collection is from Rodriguez Clara, Veracruz (no. 5494).

All have seven labials, but in two the subocular labial (fourth) is partially split. A juvenile (Veracruz), measuring 448 mm in total length (tail 110 mm), has a narrow light stripe along adjacent edges of the third and fourth scale rows, mostly on the third; a similar stripe, a little more distinct, is on the adjacent edges of the first and second scale rows. Both stripes become very faint posteriorly and completely disappear at about the middle of the body.

This species, because of the rudimentary nature of the light stripes, presence of dark spots on the scales, absence of any marked peculiarity in pattern, and its geographical position, appears to represent the nearest approach to the ancestral type of pattern in the genus. From it all other pattern types of the genus may be derived, as a northward radiation of vicariating forms in three series. With *mentovarius* as the starting point, two primary series are evident: one in which cross bands are present and one in which stripes are

developed. The latter soon splits, to give rise to the 15-scale row series, as opposed to the primitive, 17-scale row type. The pattern in the most primitive 15-scale row form (*t. australis*), however, is much like the 17-scale row form from which it possibly was derived (*bilineatus*), in respect to the stage of pattern evolution; in each the stripes are incomplete and disappear on at least the posterior fourth of the body. In the end forms of each of these two series (*i.e.*, in *lateralis*, *barbouri*, and *aurigulus* of the 17-scale row series, and in *taeniatus* of the 15-scale row series) the trend toward development of the stripes reaches its extreme, as shown by the full-length stripes. In one form (*t. ruthveni*) the pattern is very simple, and the stripes nearly absent, it is apparently a result of secondary reduction of the pattern.

In the cross-banded series, the trend is toward emphasis of the cross bands and retention of them for a longer period in the life of the individual. This trend reaches its maximum development in *piceus* and *flagellum*, and in a different form in each case. The more primitive of this series do not show any evidence whatever of the cross bands in the adults, but they do show a curious lined or spotted pattern on the individual scales. This tendency is shown somewhat in *mentovarius*, and in *striolatus* the spots at the bases of the scales are well developed. In both products of *striolatus* (*anthonyi* and *lineatulus*) the spots are replaced by a longitudinal dark line on each scale. In the next most primitive member (*flavigularis*) these lines are lost. It is of great significance that the most primitive member of the other two series of the genus (*bilineatus*) toward the southern part of its range has a longitudinal line on each scale, as in the primitive members of the cross-banded series; *bilineatus* also has such short stripes toward the southern part of its range that, save for the dark longitudinal line on the side of the head, it could easily be confused with *striolatus* of the cross-banded series.

Masticophis bilineatus Jan

Masticophis bilineatus Jan, Elenco Sist. Ofidi, p. 65. 1863 ("Messico occid?").
    —Jan and Sordelli, Icon. Gén , livr. 22, pl 6, fig. 2 (Mexico). 1867.
Masticophis semilineatus Ortenburger, Mem. Univ. Michigan Mus. Zool.
    1: 48–57, figs. 6–8, pls 11–13 1928.

Six specimens are from mainland Mexico: No 15880, Guaymas, Sonora; no. 46382, Batopilas, Chihuahua; no. 46481, San Juan Capistrano, Zacatecas; no. 46417, Pedro Pablo, Nayarit; no. 32212, Guadalajara, Jalisco; no. 46499, Cuicatlán, Oaxaca. A specimen in the EHT-HMS collection is from a locality between Autlán and Guadalajara, Jalisco (no. 23516).

All have the stripes on the anterior part of the body, and the dark stripe through the upper part of the labials characteristic of the species. In the Guadalajara specimen the lateral light stripes are confined to the nape. The specimen from Cuicatlán has still shorter light stripes, and the body posterior to the nape is almost entirely unmarked; it seems very different from the typical, northern, half-lined specimens, yet the variation exhibited by the few specimens available is so great that I can not satisfactorily define any races within the species.

The young of this species are striped, as the adult. The chief distinguishing feature from *mentovarius*, from which it seems to have been derived, is the longitudinal black line on the sides of the head, involving the upper parts of the supralabials; the remainder of the supralabials are white. In *mentovarius* there is no such black line, and the labials are more or less uniformly mottled. . In addition, the fourth and fifth labials normally are fused in the latter spe-

cies, so that only one large labial borders the orbit, but this character is not invariable (*cf.* Hartweg and Oliver, Misc. Publ. Mus. Zool. Univ. Michigan, no. 47: 19–20. 1940). The color character is invariable, however (it is believed), and is the chief reason for not considering these two forms as subspecies.

It is with little doubt that the name *bilineatus* of Jan is associated with this species. In the "Elenco" he states that the scale rows are 17, and that probably the snake came from western Mexico. In 1867 the type was well illustrated and shown to have a pattern precisely like that of the species generally known as *semilineatus*.

It is noteworthy that this is not *Masticophis bilineatus* Cope (Proc. Acad. Nat. Sci. Phila., 1866, p. 127), a name applied without description to two specimens (Field no. 777) in Schott's collection from Yucatán (U.S.N.M. no. 6555 now lost). Cope's synonymy for this name is *Herpetodryas bilineatus* Schlegel ined , Jan (Elenco Sist. Ofidi, p. 81. 1863). Cope probably used this name for the young of *Dryadophis boddaertii melanolomus*, and perhaps Jan had the same form. Regardless, however, of the identity of either Jan's or Cope's specimens, the name was suppressed by Cope in 1866, by his allocation of it to *Masticophis*, in which genus the same name was earlier proposed and diagnosed by Jan (1863).

Masticophis taeniatus australis, subsp. nov.

Holotype.—U.S.N M. no. 10240, a juvenile female from "Guanajuato," collected by Alfredo Dugès.

Paratypes.—U.S.N.M. no. 111312, Tacícuaro, Michoacán; and EHT-HMS 26227, same locality.

Diagnosis.—Scales in 15-13 rows; a continuous, unbroken white line involving adjacent edges of third and fourth scale rows, extending three-fourths length of body; no or but faint evidence of a light stripe on adjacent edges of ventrals and first scale row; anterolateral edges of middorsal scales faintly lighter, ventrals 202 in female type.

Description of holotype.—Eight supralabials, fourth and fifth entering eye and largely fused together, last three-fifths length of seventh; fifth labial in contact with temporal; loreal single, a little longer than high; two preoculars, upper very large and separated from frontal, lower very minute and in contact with two (third, fourth) labials; two postoculars, upper larger; temporals in two rows of two or three scales; nine infralabials, four in contact with chin shields.

Dorsal scales in 15-15-13 rows, smooth, those on neck with single apical pits (others pitless), ventrals 202, caudals 143; anal divided, total length 517 mm, tail 159 mm.

Dorsal surface of head uniform brown, without light edges on scales; lips white, with a very fine black line on labial border of first five labials; a fine black line on orbital edges of scales entering orbit, least evident on supraocular; a very irregular, broken black border on upper edges of preocular labials; postoculars, most of upper preocular, and anterior edge of loreal white; in temporal region the dark color of the dorsal surface involves the extreme upper edges of the last three labials, and the posterior third of the eighth labial; an irregular, vague light spot in median posterior temporal region; a dark-edged white line beginning at nape and following the adjacent edges of the third and fourth scale rows to about the posterior fourth of the body, where it disappears, below this a brown band involving the second and adjacent half rows; belly mostly white, but with a slight pigmentation lat-

erally, making barely evident a faint light line involving adjacent edges of ventrals and first row of dorsals, this line disappears completely a little anterior to the point where the other line disappears. Posterior fourth of body and tail more or less uniform brown. Dorsal scales between stripes brown, their anterolateral edges lighter, their extreme anterior edges black. Tail white below, slightly stippled anteriorly.

Variation.—The two paratypes from Tacícuaro are also juveniles, as the holotype, and agree exactly with the latter in coloration. The ventrals of neither can be counted, but the caudals in one (male) are 147, in the other (female) 143. Supralabials 8-8 in each, infralabials 10-10, 11-11; oculars, temporals and scale rows as in type.

Remarks.—The closest relatives of *australis* appear to be *girardi* and *schotti*. Since the former is known from localities much nearer the range of *australis*, perhaps it is more closely related to the southern subspecies than is *schotti*, although *australis* certainly resembles the latter more closely From *schotti*, *australis* differs by having no or very faint evidence of a light line on the adjacent edges of the ventrals and the first row of lateral scales; the belly in *schotti* is strongly pigmented laterally, except toward the posterior part of the body, while in *australis* the belly is almost uniform white, with very little stippling. From *girardi*, *australis* differs by lacking dark marks on the belly, by the presence of only a single lateral light stripe on the adjacent portions of scale rows three and four, by the absence of dark lines on the lateral scale rows, and (?) by the absence of light edges on the dorsal head scales I have not seen young *girardi*, but according to Ortenburger "the pattern of the young of this species is somewhat different from that of the adult. The light cross-bands are absent except for a very narrow first dorsal band just behind the head. There is present a black median stripe through scale row 1; row 2 is brown with light lower edge; the lower half of row 3 is black, the upper half cream; row 4 is either all cream, or the lower half or two thirds cream, and upper third or half, black, row 5 is either dark like the remainder of the dorsal surface, or the lower fourth is cream and the upper three fourths dark. The light stripe on rows 3 and 4 is the only wide one present and, unless close examination is made, the general impression is that there is present but a single light lateral stripe. There is a dark brown spot on the anterior ends of those scales of row 4, which will, in the adult, be between the light interruptions The regions which will be occupied by the light cross-bands and interruptions of the adult are already indicated by the lack of the anterior dark marks on the cream-colored scales of row 4. The belly is mottled only about half the way to the tail" (pp. 37-38)

Accordingly, while adults of *australis* are not yet known, the young available do not appear referable either to *girardi* (as it is known in the United States) or to any other previously described form. It should be remarked, however, that the young of the extreme southern *"girardi"* (e g., Zacatecas, southern Coahuila), the adults of which, like *australis*, lack the light edges on the dorsal head scales (present in northern, typical *girardi*), are not yet known; it is not impossible that they may prove to lack the juvenile characters of typical *girardi*, and be referable to *australis*.

Specimens of *australis* apparently were referred by Ortenburger to two other subspecies. The type was included with *t. taeniatus*, but from this it differs in so many pattern characters that they need not be enumerated here. On the basis of this specimen the range of *t. taeniatus* was conceived to include a portion of the central Mexican plateau. Present evidence does not verify its occurrence south of Lake Santa María, Chihuahua. The single rec-

ord (other than from Guanajuato) of *t. taeniatus* given by Ortenburger for areas south of central Chihuahua, is (apparently) San Pedro, Coahuila. If this record is correct, then it represents the extreme eastern edge of the range of the subspecies in this area, for a specimen of this group in the National Museum from a locality five kilometers southeast of San Pedro proves to be *girardi*. There is another specimen available of *girardi*, from central Zacatecas (La Colorada), which strongly indicates that, if *t. taeniatus* occurs south of Chihuahua, it must be confined to the extreme western edge of the plateau (from which area no specimens of the group are yet available); such a distribution does not seem very probable.

The remaining specimens, apparently of *australis*, available to Ortenburger, were referred by him to *ruthveni*. They are from San Luis Potosí (M C.Z. nos. 19027–32) and are described as being striped, while the true juveniles of *ruthveni* are not (see discussion of latter)

The subspecies *australis* is perhaps the most primitive of *taeniatus*. Although *ruthveni* may appear to have the most primitive pattern, since in it the stripes are the least well defined of all, it seems only to represent a secondary obsolescence of pattern, perhaps from a type shown by the juveniles of *australis*. Intensification of the pattern of *australis* characterizes *schotti*, certainly a derivative of the former. These three form a unit opposed to the other (*taeniatus* and *girardi*), it is characterized by (1) the presence of light anterolateral edges on the middorsal scales, by (2) the narrowness of the light stripes, and by (3) the absence of light edges on the dorsal head scales [2]

The subspecies *girardi* apparently also was derived from *australis* but at an earlier date than the others, since it typically lacks the light anterolateral edges on the dorsal scales and has broader light lines. Its close association with the *schotti* unit, however, is indicated by the absence of light edges on the dorsal head scales in southern specimens, and by apparent intergradation with *schotti*, and probably with *australis* M. *t. girardi* has short, light stripes, as does *schotti* and *australis*, and in this respect differs from *taeniatus*, in which the light stripes (at least the primary) extend the full length of the body.

Masticophis taeniatus ruthveni Ortenburger

Five specimens of this form have been examined: TAMAULIPAS. 22 km north of Victoria (no. 11443), Soto La Marina (no. 37546); 50 miles south of Brownsville, Texas (no. 64681). SAN LUIS POTOSÍ: 35 km. northwest of Ciudad Maíz (EHT-HMS 23517). MICHOACÁN: Zamora (EHT-HMS 21452).

Ortenburger (p. 46) states: "In one specimen, not fully grown (M.C.Z , no 13951), a light lateral stripe ['covering adjacent parts of rows 3 and 4, bordered by black' (p 21)] is present and continues the length of the body. Another specimen (U.S.N.M , no. 1974), very young, shows this light lateral stripe also, and except for the fact that the typical yellow marks on the dorsal scales are lacking it is quite similar to *schotti*. Six other young specimens were received from San Luis Potosí (M.C.Z. 19027–19032). These likewise show the lateral light stripe and lack of the light marks on the dorsal scales."

U.S.N.M. no. 1974 was from Matamoras, Tamaulipas, and is labeled in the catalog "*schotti*," but is now lost. In view of Gloyd and Conant's work (Occ. Pap. Mus. Zool. Univ. Mich., no. 287: 1-17, pls. 1-3. 1934) on this form and *schotti*, there can be but little doubt that this specimen was either a young *schotti* or else a *schotti-ruthveni* intergrade. Probably M.C.Z. no.

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[2] The first and third characters need verification in adult *australis*, that they exist in present specimens of that form may be simply a juvenile characteristic

13951 is the same, while M.C.Z. nos. 19027–32 almost certainly belong to *australis*. That none of these have the light marks on the anterolateral borders of the dorsal scales is rather obviously a juvenile character.

That the young of true *ruthveni* are not striped is shown by EHT-HMS no. 23517, from Ciudad Maíz. This specimen measures 495 mm in total length, the tail 160 mm. In color and pattern it is precisely like typical adult *ruthveni*, save that the dorsal scales are but very faintly light-edged anteriorly. No distinct stripes whatever are evident anteriorly, a faint, threadlike light line is visible on the neck at the lower edge of the fourth scale row, but in no sense is this similar to the lateral light line of *schotti* or *australis;* adult *ruthveni* also show an exactly similar line (see Ortenburger, pl. 9).

The most extraordinary specimen in the entire series is an apparently perfectly typical adult *ruthveni* from Zamora, Michoacán, a locality so far removed from others from which the subspecies is known that it is impossible to guess the significance of this record Unfortunately the snake is badly crushed, having been found on a road. Its scale rows, supralabials, and oculars are typical; the dorsal surface is nearly uniform blue-green, except for yellowish borders on the extreme anterolateral edges of the median rows of dorsals; no stripes are present, except a very faint one anteriorly along the adjacent edges of the ventrals and first scale row.

This specimen may be just what it appears to be—a typical *ruthveni;* but if so a broad overlapping of the ranges of *australis* and *ruthveni* is indicated. Regardless of the manner of interpretation of this specimen and its significance, a considerable juggling is necessary in order to reconcile all known facts, so much hinges upon this specimen alone that speculation upon it should await verification of the record by further material.

Masticophis taeniatus girardi (Stejneger and Barbour)

Four specimens are known from Mexico, from "Chihuahua" (no. 14272); La Cuchilla, 5 miles south of San Pedro, Coahuila (no 105300), 14 km. northeast of Pedriceña, Durango (EHT-HMS), and La Colorada, Zacatecas (EHT-HMS no. 5437, described by Dunkle and Smith, Occ. Pap. Mus Zool. Univ. Mich., no 363. 5–6. 1937). These lack the light borders on the dorsal head scales, typical of northern specimens.

Masticophis taeniatus taeniatus (Hallowell)

A single Mexican specimen examined is from Lake Santa María, Chihuahua (no. 46594).

Masticophis flagellum striolatus (Mertens)

Coluber striolatus Mertens, Zoologica 32: 190. 1934 (*nom. nov.* for *Coluber lineatus* [Duméril and Bibron], preoccupied by *Coluber lineatus* Linnaeus).

Masticophis lineatus Ortenburger, Mem. Mus. Univ. Michigan 1: 134–138, fig. 27, pl. 25. 1928.

Twenty-three specimens are in the collection: Nos. 24680–2, María Magdalena, Tres Marias Islands; no. 46483, Acaponeta, Nayarit; no 46386, Atemajac, Jalisco, no. 111278, Coyuca, Guerrero; no. 111277, 10 km. south of Cuernavaca, Morelos; nos. 32178, 32221–2, 32232–3, 62027–9, 62031–4, Colima, Colima; no. 32344, Zacatula River, near Lauria, Guerrero; no. 62026, Sierra Madre, Chacan River, Michoacán; no. 62030, Hurcha Volcano, plains of Nuruapa, Michoacán.

The original description (of *lineatus* Duméril and Bibron) appears to be a composite, based partly upon *striolatus* as at present defined and partly upon *lineatulus*. Fortunately a specimen from Colima is mentioned, which, for geographic reasons, probably is *striolatus* as at present understood.

Small specimens show traces of cross bands anteriorly, but in this form the banded pattern is less distinct than in any other of the species. This form is so obviously a close relative of *lineatulus*, which occurs in adjacent territory, that I believe there is little doubt they are subspecies. It moreover appears that *striolatus*, not *flavigularis*, as suggested by Ortenburger, is the most primitive form of the species *flagellum*.

Masticophis flagellum lineatulus, subsp. nov.

Holotype.—U. S. N. M. no. 105292, female, from a locality eleven miles south of San Buenaventura, Chihuahua.

Paratypes —Thirteen in the U S. National Museum: No. 12676, Guanajuato; nos. 14279, 14283, Chihuahua; no. 26151, "Mexico"; no. 46355, Guanacevi, Durango, no. 1988, Alamo de Parras, Cohuila; nos 104675-6, Río Santa María, near Progreso, Chihuahua; no. 1989, Cobre Mines, New Mexico; no. 4388, Laguna, N. Mex., no. 8429, "New Mexico"; no. 22142, Las Cruces, N. Mex.; no. 102240, Jornada Experimental Range, Doña Ana County, N Mex. One in the Museum of Comparative Zoology, no. 14280, from Las Cruces, N. Mex One in the EHT-HMS collection, no. 5388, between Torreón and San Pedro, Coahuila.

Diagnosis.—Scales in 17 rows, posteriorly 12 or 13; ventrals 190 to 198, caudals 99 to 110; posterior portion of belly and subcaudal surface red or marked with red (except in juveniles), even in long-preserved specimens (red not fading greatly), each dorsal scale with a longitudinal dark line or a posterior dark spot; head scales not light edged in young, no light loreal stripe (center may be light), young with cross bands 2 or 3 scales long, extending laterally to ends of ventrals, disappearing on middle of body

Description of holotype — Rostral rather prominent, strongly pointed posteriorly, as high as wide, portion visible from above as long as internasals, latter three-fourths length of internasals, frontal twice as broad anteriorly as between middle of orbits and posteriorly, about as long as its distance from tip of snout, very slightly shorter than frontal; nasal completely divided, anterior section a little larger and higher than posterior; loreal a little longer than high, in contact with two labials and lower preocular; two preoculars, upper in contact with frontal, lower much smaller and wedged between third and fourth supralabials; two postoculars, upper a little the larger; two irregular rows of temporals, an anterior temporal wedged between fifth and seventh labials, above sixth (which is small); eight supralabials, fourth and fifth entering orbit, fifth in contact with a temporal, seventh and eighth larger than others; infralabials 10-11, four in contact with anterior chin shields, two with posterior, fifth much the largest; anterior chin shields shorter, and a little broader, than posterior.

Dorsal scales smooth, with double apical pits, in 17-17-12 rows; ventrals 197; anal divided; tail incomplete. Total length 1,481 mm, tail 336 mm (plus a few mm).

Color.—Head light yellowish brown, darker toward posterior sutures; sides of head light yellowish brown, with a lighter area in the preocular, loreal, nasal and rostral; a dark, rounded spot in center of nasal; supralabials white (cream) below a line about even with posterolateral border of seventh labial and middle of subocular labials.

Dorsal ground color light yellowish brown, becoming more reddish toward middle of body, posteriorly mostly salmon red; all anterior dorsal scales with a central, longitudinal black streak, which becomes more spot-like on scales in middle of body, barely indicated on posterior scales; as the black spots become less distinct, the red areas become more distinct, the posterior scales being mostly red (with a little black near tip), with a white (cream) base; dorsal surface of the tail is even more strongly marked with salmon red.

Posterior edge of mental and broad areas near the sutures between the infralabials and chin shields, black-marked; a double row of black spots beginning with anterior ventral scales; posteriorly these spots becoming mixed with red and soon mostly red and very little black; anterior ground color of belly yellow, this color extending onto lower dorsal scale rows; toward middle of belly the color is largely replaced by salmon red, and posteriorly the belly is entirely red, with the double row of black spots faintly indicated; ventral surface of tail mostly red, the bases of the scales lighter (cream).

Variation.—The variation in scutellation is given in Table 1. In coloration the adult and subadult paratypes agree with the holotype, except that those long preserved have lost much of the original color. Without a single exception, however, every adult shows the typical salmon red color at least on the subcaudal surface.

Two very young specimens are from "Guanajuato" and "Mexico," both collected by Dugès and therefore probably from the vicinity of the city of Guanajuato. In these the dorsal head scales are not light-margined, sides of head with numerous vertical light marks, one on frontal; a light spot in loreal (not a stripe) and another on posterior section of nasal. Anterior part of body darker than posterior, and with narrow light cross bands covering considerably less than one scale length, placed at intervals of two or three scale lengths; these light cross bands extend to ventrals, somewhat irregular middorsally; tail, and middle and posterior part of body unmarked, becoming lighter posteriorly.

TABLE 1.—SCALE COUNTS IN MASTICOPHIS FLAGELLUM LINEATULUS

Number	Sex	Scale rows	Ventrals	Caudals	Supral	Infral.	Proc.	Ptoc	Temp.
1989	♀?	17–12	198	100	8–8	10–10	2–2	2–2	2–2
8429	♀	17–13	198	107	8–8	9–10	2–2	2–2	2–2
12676	♀	17–13	194	110	8–8	11–12	2–2	2–2	2–2
14279	♀	17–12	190	—	8–8	12–13	2–2	2–2	2–2
14283	♀	17–12	194	100	8–8	11–11	2–2	2–2	2–2
26151	♀	17–13	191	109	8–8	10–11	2–2	2–2	2–2
105292	♀	17–12	197	—	8–8	10–11	2–2	2–2	2–2
1988	♂	17–12	—	—	—	—	—	—	—
4388	♂	17–12	189	106	8–8	10–11	2–2	2–2	2–2
22142	♂	17–12	199	—	8–8	10–12	2–2	2–2	2–2
46355	♂	17–12	196	99	8–8	10–11	2–2	2–2	2–2
102240	♂	17–13	200	—	8–8	9–10	2–2	2–2	2–2
104676	♂	17–12	198	105	8–8	11–11	2–2	2–2	2–2
104675	♂	17–12	198	107	8–8	11–11	2–2	2–2	2–2

A young specimen, from "New Mexico," appears to be an intergrade between *lineatulus* and *flavigularis*, as it has the striped pattern anteriorly of the former, in addition to two narrow, widely separated dark cross bands typical of juvenile *flavigularis*. Another specimen, also young, from Doña Ana County, N. Mex., appears to be an intergrade, as it has dim evidence anteriorly of cross bands somewhat like those of juvenile *flavigularis;* the

specimen is so nearly grown, however, that the nature of the cross bands is not readily discerned; the striped pattern anteriorly is distinct and typical of *lineatulus*. A specimen in the University of Michigan Museum of Zoology, from 8 miles north of Hereford, Ariz. (no. 69668) closely approaches *lineatulus*, differing only by having a light loreal stripe as in *piceus* (see color description by Gloyd, Bull. Chicago Acad. Sci. 5: 117–118. 1937).

Remarks.—The adults of this subspecies are readily distinguishable from *flavigularis* and *piceus* by the striped scales; they also lack the loreal stripe
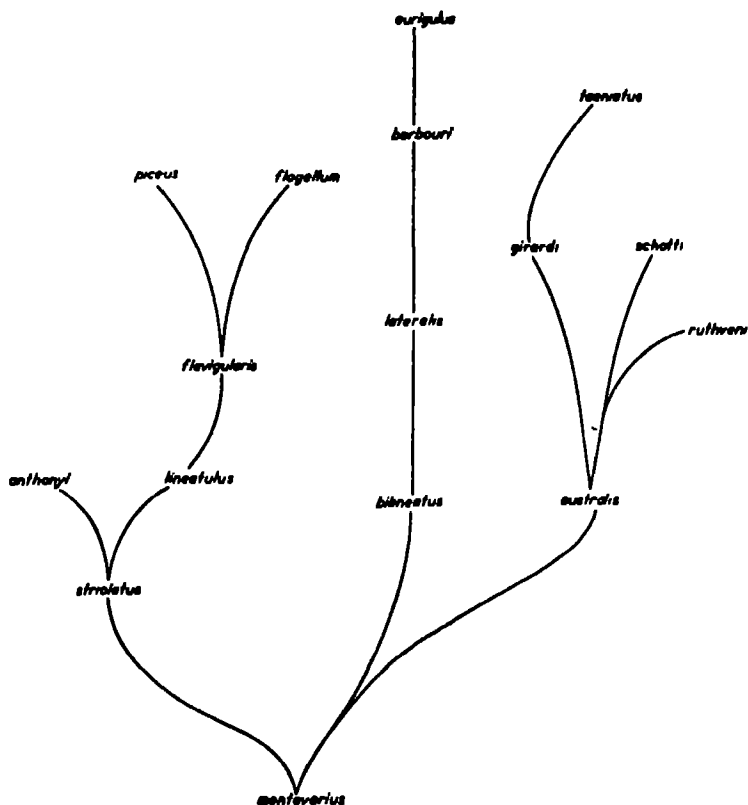
Fig 1.—Possible phylogeny of the members of *Masticophis*.

of the latter. Preserved *lineatulus* also retain the red ventral color, while *flavigularis* and *piceus*, although frequently brilliant red in life, lose this color very quickly in preservative.

The young of *lineatulus* are strikingly different from those of *flavigularis*, with narrow, dark cross bands; *piceus*, with a light loreal stripe and the two or three anterior dark bands broad and very dark (black), those following conspicuously lighter; and *striolatus*, with light margins on the dorsal head scales.

Ortenburger anticipated the separation of this subspecies in his discussion of *flavigularis*, with which specimens of *lineatulus* were associated. "One specimen (M.C.Z., no. 14280) is particularly interesting in that it approaches

piceus in ventral coloration and number of ventrals. The belly is red like that of the typical *piceus* of the west [but which does not retain this red in preservative], and moreover it has 202 ventrals, a much higher number than would be expected for *flavigularis* It is from the western part of the range of the form—Las Cruces, Doña Ana County, New Mexico. Four other specimens show a similar coloration. Two of these are from Chihuahua and another from Durango, and another from San Luis Potosi. A singular dorsal coloration is exhibited by all these specimens. Practically all the dorsal scales have an elongate median dark mark. Whether these very few interesting specimens will eventually be considered as belonging to a distinct form cannot now be determined" (pp. 102–103).

Masticophis flagellum flavigularis (Hallowell)

Six specimens: NUEVO LEÓN: 15 miles north of Monterrey (no. 111268); Pesquieria Grande (no. 1995), Santa Caterina (no 1992), TAMAULIPAS. Mier (no. 48091). SAN LUIS POTOSÍ: Chijol (no. 46476). SONORA: San Bernardino Ranch (no. 21052). All are typical adults, of nearly uniform light brownish-gray color.

Juveniles have very narrow, dark cross bands, and in this respect they differ from the young of all other subspecies.

The record from extreme northwestern Sonora is substantiated by another specimen of *flavigularis* from Apache, Ariz. (no. 8428, juvenile). These two specimens lack the loreal stripe and dark anterior cross bands of *piceus* and also the red ventral color and striped scales of *lineatulus* The subspecies *flavigularis* apparently surrounds the latter north of the United States-Mexico boundary.

Masticophis flagellum piceus (Cope)

The only specimen from mainland Mexico is one from Altata, Sinaloa (no. 33570).

Juveniles of this subspecies have a distinct white loreal stripe, as has previously been pointed out, the cross bands on the body extend to the ventral surface; the posterior part of the body is considerably lighter (uniform) than the anterior (banded); and the extreme anterior nuchal bands are darker than the succeeding bands. In Arizona and Sinaloa specimens the dorsal head scales usually are light-edged, and the anterior cross bands are less distinctly differentiated from the succeeding bands; California specimens usually do not have the dorsal head scales light-edged, and the anterior cross bands are very well differentiated from (darker than) the succeeding bands.

It is obvious that the black phase for which the name *piceus* has generally been used can not have arisen by the same procedure as have all other members of *Masticophis* recognized at present. It is, almost beyond question, a mutant form, occurring within the range of "*frenatus*"; it does not seem of greater significance than the red phase of the same species. Taylor (Kansas Univ. Sci. Bull 24: 491. 1936 [1938]) describes a specimen in which only "the anterior half of the body is black. About the middle of body there are three, black-spotted, reddish bands, while the latter third of the body is more or less reddish. The specimen was captured in the heat of the day under a flat rock, near La Posa [Sonora]." It is unfortunate that the name of an atypical phase must, because of priority, be used for the species; such is the case, however, in this form, for *piceus* (1892) antedates the only other name (*frenatus*, 1893) that has been applied to this race. The latter name, more-

over, is not available under any circumstance, since it is a suppressed homonym of *Herpetodryas frenatus* Gray (Ann. Mag. Nat. Hist. (2) **12**: 390. 1853.) from India, placed in the genus *Coluber* (*Coluber frenatus*, a valid species) by Boulenger (Fauna Brit. India, Rept., p. 335. 1890). If the California specimens are ultimately distinguished from Arizona ones, or if the name *piceus* is restricted to the black phase, a new name or names will be required.

<div align="center">KEY TO MAINLAND MEXICAN MASTICOPHIS</div>

1. Scales in 15 rows....   2
   Scales in 17 rows.....   6
2. A distinct lateral light stripe involving edges of third and all or adjacent edge of fourth row.   4
   No distinct lateral light stripe involving third and fourth rows   .
   ....   *taeniatus ruthveni*
3. Upper lateral light stripe involving fifth row of scales..   .   4
   Upper lateral light stripe confined to adjacent edges of third and fourth rows, always continuous   5
4. Lateral light stripe broken or partially interrupted anteriorly, not reaching anal region..   *taeniatus girardi*
   Lateral stripe continuous and uniform in character throughout its length, reaching anal region...   .   *taeniatus taeniatus*
5. A very distinct, light lateral stripe on adjacent edges of ventrals and first row of dorsals; young and adults   .   *taeniatus schotti*[3]
   No or only faint evidence of a lateral light stripe on adjacent edges of ventrals and first row of dorsals; young only (adult not known)
   .   .   ..   .   *taeniatus australis*
6. A single labial entering orbit..   . .   *mentovarius*
   Two labials entering orbit   7
7. No longitudinal light stripes exclusively on lateral rows anteriorly; if present, equally distinct on dorsal as on lateral rows   9
   Lateral light stripes present anteriorly, these more distinct than dorsal light stripes (if any)   8
8. Lips mottled..   .   *mentovarius*
   Lips mostly white, bordered above by black   .   *bilineatus*
9. In young, neck bands much darker than succeeding bands, considerably broader than spaces between them; in adults, neck bands always visible, a longitudinal white stripe through loreal   .   *flagellum piceus*
   In young, neck bands not greatly darker than those following, in adults, if bands are visible, they are narrower than the spaces between them; no distinct white stripe through loreal   10
10. Caudals 109 or more; a dark spot at the base of each scale; usually no dark lines through the centers of anterior scales   . *flagellum striolatus*
    Caudals usually less; no dark spots at the bases of the scales, or if so a dark line through the center of the anterior scales   11
11. In adults, a dark line through the center of each scale at least on anterior part of body, and at least subcaudal surface salmon red *in preserved specimens;* in young, the dark bands broader than the light interspaces, which are incomplete and irregular ....   *flagellum lineatulus*
    No dark lines through centers of scales; ventral surfaces not red except in live or very recently preserved specimens; young with narrow dark crossbands, narrower than light interspaces, which are complete
    .   .   .   *flagellum flavigularis*

[3] Not yet recorded from Mexico, but almost certainly occurring.

ZOOLOGY.—*Notes on* Squilla empusa *Say.*[1]   ROBERT PAYNE BIGE-
   LOW, Massachusetts Institute of Technology.   (Communicated
   by WALDO L. SCHMITT.)

The purpose of this paper is to place on record some observations
made under especially favorable circumstances upon the coloration of
Squilla empusa Say (1818), including a few notes on the behavior,
external anatomy, and sexual dimorphism of this stomatopod crus-
tacean, thè only one found normally in the vicinity of Woods Hole,
Mass.

Squilla empusa is known to range southward to the Gulf of Mexico
and Texas. It has been found also in the West Indies and has been re-
ported from west Africa. Buzzards Bay appears to be the northern
limit of its distribution, and, while the pelagic larvae are occasionally
abundant in the plankton, adults are rarely taken (Sumner et al.,
1911). Only a few specimens are brought into Woods Hole from time
to time by scallop, *Pecten (Plagioctenium) irradians* Lamarck, or
quahaug, *Venus mercenaria* Linnaeus, fishermen. In September 1931,
however, a number of half-grown specimens were taken with the seine
in the Wareham River; and on several trips made between the first
of August and the last of September 1932, large numbers of adults
were captured by Robert A. Goffin, of the U. S. Fisheries Biological
Station, with a shrimp-trawl in Mattapoisett Harbor and in Wareham
River, on the north shore of Buzzards Bay.

Although in Woods Hole at the time, I was unaware of these events
until—just as I was about to leave—my attention was called to an
exhibit in the public aquarium room of the Fisheries Station. In a big
glass aquarium, close by a large window of frosted glass, were 21
adults selected from some hundred specimens taken by Mr. Goffin
with the otter shrimp-trawl at a depth of about 3 fathoms in Matta-
poisett Harbor on September 6, 1932. The specimens were lively and
in excellent condition, visible from all sides, and brilliantly illuminated
by diffused sunlight during the morning hours. Their coloration was
striking. This is a feature usually neglected in taxonomic works (cf.
DeKay, 1844; Bigelow, 1895; Pratt, 1916), and here was an oppor-
tunity not to be missed. As the time at my disposal was short, I made
careful notes without waiting to consult the literature. Thus my ob-
servations were made independently of the detailed but rather in-
complete descriptions of Say (1818, p. 252) and of Verrill and Smith
(1873, p. 369), and for that reason, perhaps, they may be worthy of
record.

[1] Received April 14, 1941.

COLOR PATTERN

As seen in the aquarium, the animals were ornamented on the dorsal side by a ground color and by markings in various other colors that produced a brilliant pattern. The ground color was an opalescent purple—described by another observer as "mauve," or gray with a tinge of violet. Across the median area of the somites of the hind-body were transverse shadowy gray patches, most marked on the second abdominal somite.

Aside from these indistinct patches, the markings were mostly green, opaque white, yellow, and orange. The green color marked the projecting portions of the integument. On the posterior border of the carapace and of each somite of the hindbody there was a band of apple green shading anteriorly into a deep olive-green. The bright-yellow edge mentioned by Say and by Verrill accentuates the light green on the margins of the carapace and the last two abdominal somites. Except for the marginal carinae of the abdomen, each carina, from the rostrum to the telson, and the basal bosses of the marginal teeth and denticles of the telson were marked by green in the same way. On the dorsal surface of the telson each one of the pits on each side of the crest appeared as a light-green spot. Also the dorsal carina on the propodus of the raptorial limb is light green, while the margin of the ventral groove of the merus is purple, the two colors coming close together when the claw is closed.

The opaque white markings on the body consist of fine lines and spots in a symmetrical pattern on the submedian area of the thoracic and abdominal somites, and of large irregular patches lateral to the intermediate carinae of the thorax and of the abdomen and between the lateral and marginal carinae of the abdomen, extending to the flattened surface of the marginal carinae. The mobile spines of the uropods are entirely white, and the same color appears on the tips of the submedian and intermediate teeth of the telson and of the prongs of the basal process of the uropods, and along the outer margins of the pleopods. The thoracic limbs are pinkish white.

The antennal scales are yellow toward the apex, while a deeper yellow marks the outer half of the paddle of the uropods. The color scheme is completed, in the main, by broad fringes of setae that bor-der the antennal scales, the pleopods, and the uropods. These are a shade of orange that forms a strong contrast to the other colors.

The eyes are among the most striking features of these animals. Both Say and Verrill describe them as brilliant emerald-green. In our specimens the outer layers of the cornea were perfectly transparent,

and within could be seen a dark mass with a brilliantly iridescent metallic luster. The eye stalks were translucent with a pinkish or orange hue.

If this more detailed description is compared with that of Say or of Verrill and Smith, it will be found to differ in many particulars. It differs fundamentally from the description and figure of DeKay (1844, p. 33, fig. 54).

It is well known that some Crustacea change color with a change of background (Keeble and Gamble, 1904; D. C. Smith, 1930; F. A. Brown, 1935). Late in the summer of 1933 it was suggested to me that *Squilla empusa* may be one of the variable species. To test this an attempt was made to obtain material for experiments, but a day of strenuous dredging, September 14, yielded only one specimen where the species had been abundant the year before. Without an ample supply one could not expect significant results. Nevertheless, this one large female was subjected to a series of experiments with apparatus kindly lent by G. H. Parker at the Marine Biological Laboratory, and no change in color was observed. That result is perhaps to be expected of an animal that spends part of its life in a burrow. If there is any change, it may be very slow, as in the crayfishes (Kent, 1901).

BEHAVIOR

While notes were being made of the color the animals were constantly in motion. Even those that were resting on the bottom exhibited rhythmic, fanlike movements of the epipodites on the first five pairs of thoracic limbs. These movements of the epipodites were not in phase with the similar rhythmic motion of the gill-bearing abdominal appendages, the pleopods. It was amusing to observe the use that frequently was made of the first thoracic limb to clean the body. By means of the brush of setae on the terminal segment, first the adjacent limbs were thoroughly scrubbed, then the body was bent so that other parts could be reached, until finally a complete toilet had been accomplished, including all the abdominal appendages and gills.

Locomotion on the bottom was by alternate movements of the three pairs of thoracic walking legs; but change from place to place was chiefly by swimming with progressive oarlike strokes of the pleopods. Occasionally a sudden backward movement was made by a powerful flexure of the hindbody. Application of the net handle to the antennules of a resting individual evoked a stroke of the raptorial claws that was startling in its swiftness and force.

There were small fishes in the aquarium. They were frequently pursued. The capture was observed of a menhaden about 5 cm in length. This was accomplished by bilateral grasping movements of the raptorial limbs. The fish was quickly bitten cleanly in two. The posterior half dropped to the bottom. There it was found and eaten by another squilla while the captor was consuming the other part.

<div align="center">STRUCTURAL FEATURES</div>

Opportunity to supplement previous descriptions of the structural features of this species is afforded by the courtesy of Mr. Goffin, who placed in my hands two males (76 and 145 mm) and three females (97, 105, and 180 mm) preserved from the catch of September 6, 1932; and also a male (150 mm) taken with a scallop-dredge in Buzzards Bay at North Falmouth in November 1926.

The facts to be recorded are in two groups—first, referring to the affinity of this species to other species of the genus; and, second, relating to sexuality.

In the first group should be noted the presence of mandibular palps with three segments; epipodites at the bases of all of the first five thoracic limbs; and an abdominal spine-formula (Kemp, 1913, p. 9), as follows:

Carinae ending in spines						*Abdominal somites*
Submedian					5	6
Intermediate			(3)	4	5	6
Lateral	(1)	2	3	4	5	6
Marginal	1	2	3	4	5	

The carpus of the raptorial limb, when fully developed, bears a dorsal crest with four sharp teeth, the distal one out of line with the others. The exopodite of the uropods is armed with 8 or 9 (rarely 6) mobile spines, the distal one acute, not greatly elongated, and curved toward the apex of the limb.

<div align="center">SEXUAL DIMORPHISM</div>

Of special interest are the differences in the sculpturing of the telson and the abdominal somites to be seen by comparing young with old of both sexes and fully grown males with females of the same age. These differences were well marked in the six specimens examined at Woods Hole. In the two smaller females and the small male the crest and marginal carinae of the telson have sharply defined summits; and the marginal carinae of the abdomen, separated by a distinct groove from the edge of the somite, are but slightly wider than the other carinae and each one is distinctly grooved longitudinally. In the large

female (180 mm) and the two large males (150 and 145 mm in median length) the sculpturing of the telson is alike and differs from that of the smaller specimens in having the crest and marginal carinae swollen and broadly rounded at the summit.
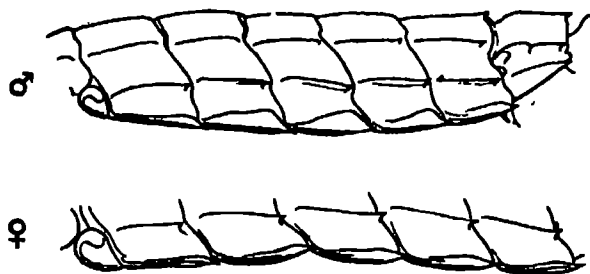
Fig 1 —*Squilla empusa*: Six abdominal somites of a male 150 mm long and lateral and marginal carinae on the abdomen of a female 180 mm long Left lateral aspect, natural size

On the other hand, the marginal carinae of the abdomen in these large individuals exhibit distinct sexual differences, as shown in Fig. 1. On the third abdominal somite of the large female these carinae are grooved on the anterior third of their length and the posterior two-thirds is broad (about one-tenth the length) and distinctly swollen. This feature is progressively less marked on the other somites toward each extremity of the abdomen. The two large males differ from the female in having these carinae very much broader (maximum width about one-fourth the length) with the summit a broad flat plane—not at all grooved, except slightly on the first abdominal somite.

Thus our species shows distinctly in one feature, previously overlooked, some of the sexual dimorphism, that is conspicuous in several closely related species of the Panama region.

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ORNITHOLOGY.—*Bird bones from Eskimo ruins at Cape Prince of Wales, Alaska.*[1] HERBERT FRIEDMANN, U. S. National Museum.

In the summer of 1936, H. B. Collins, Jr., of the Bureau of American Ethnology, excavated a number of old Eskimo habitations in the Cape Prince of Wales area, Alaska, and collected, among other material, a large number of bird bones. All the material was carefully labeled with full stratigraphical data, thereby preserving the relative ages of the various specimens. The antiquity of the sites and the levels of the different cuttings have been estimated from archeological evidence by Collins (Smithsonian Misc. Coll. 100: 545. 1940) as follows:

The oldest site, the Sand Mound near the Light House, 2 miles north of Wales, is considered to be about 1,500 years old; a series of numbered cuts (1–10) are next in age—1,000 years, as are also the basal layers of two cuts "above A and B"; two sites named Mugisaktavik and Eyumnik are next in age, with an estimated 100–150 years; finally come a series of excavations "A, B, C, and D," assumed to be 50–100 years old.

The bulk of the material coming from the older diggings (1,000–1,500 years old) are of the Punuk-Thule archeological level and are, therefore, comparable to the diggings from Ievoghiyoghamcet and the upper part of Myiowaghameet at Gambell, St. Lawrence Island (reported in Journ. Washington Acad. Sci. 24: 83–96. 1934). A comparison of the present lot of bones with the Gambell series reveals some striking differences, but differences that seem to reflect dissimilarities in the bird life of the two areas, rather than in any differential human selectivity.

In the material collected on St. Lawrence Island, bones of the murres (*Uria*) were by far the most abundant elements of the bird remains, totaling about 60 percent of all the bones collected; in the Cape Prince of Wales collection only a moderate number of murre bones were found, and they were far exceeded numerically by remains of the king eider. In the former area there are cliffs that harbor breeding colonies of murres; in the latter area there are none, and it seems that this is the reason for the dissimilarity in the collections, rather than any great proclivity for murres of the St. Lawrence Eskimos, as contrasted with the Wales Eskimos. Other minor differences are noted under the separate species accounts.

The chronology of the cuttings involves only a span of not more

than 1,500 years, and, as might be expected, it reveals no changes in the bird life of the area.

Gavia immer (Brünnich): Common Loon

The common loon is represented by bones from five cuttings, ranging from the most recent (50–100 years old) to the oldest (over 1,000 years) strata. In the oldest one, eight bones representing at least three individuals were found; in the others, only single bones were collected.

Gavia adamsi (Gray): Yellow-billed Loon

Five cuttings considered to be of the Punuk-Thule period (1,000 years old) each yielded a single bone of this species.

Gavia arctica pacifica (Lawrence): Pacific Loon

The Pacific loon is represented by bones from nine cuts, all of the Punuk-Thule period, and also from the oldest site—a few centuries older. The largest number of bones in any one cut was three, so this species cannot be looked upon as a very frequently eaten article of diet. The actual specimens identified are five carpometacarpals, five tarsometatarsals, four humeri, two tibiotarsi, and a pair of mandibles.

Gavia stellata (Pontoppidan): Red-throated Loon

Bones of this bird were collected in five cuttings, all of about 1,000 years antiquity. The bones included four tibiotarsi, one radius, one ulna, one pair of mandibles, and two coracoids.

Puffinus tenuirostris (Temminck): Slender-billed Shearwater

The old cuttings (1,000 years) yielded a single humerus each of this shearwater. It would seem from this that the slender-billed shearwater was rarely eaten by the Eskimos of the area.

Phalacrocorax pelagicus pelagicus Pallas: Pelagic Cormorant

Sites of all ages from 50 to 1,500 years yielded bones of this cormorant. In the oldest cut, that of the Sand Mound near the light house, were found the greatest number—three femurs, two coracoids, three ulnae, three tibiotarsi, and seven humeri; in the others the number was smaller—from one to three bones.

In a report on a similar collection of bird bones from Eskimo ruins on St. Lawrence Island (Journ. Washington Acad. Sci 24: 88. 1934) it was noted that "although many limb bones were found, only four synsacra and one sternum were unearthed and no parts of the skull or mandibles." In the present collection, there is a similar absence of skull bones and sterna, and only one synsacrum was recovered. Inasmuch as sterna, synsacra, and skulls of other birds of similar size, especially the eider ducks, are present in numbers, together with their corresponding limb bones, it is difficult to explain their absence in the case of the cormorant.

Branta canadensis (Linnaeus): Canada Goose

Bones of this species, but not certainly identifiable to subspecies, were found sparingly. Five sites yielded one bone each The Eyumnik cut revealed a femur and in four of the excavations of Punuk-Thule area, there were un--earthed two ulnae, one humerus, and one carpometacarpal.

Branta nigricans (Lawrence): Black Brant

The black brant is represented in the material collected from five old (Punuk-Thule period) diggings, and from one recent (50–100 years old) one. The old sites yielded a single bone each; the recent one, two humeri.

Philacte canagica (Sevastianoff): Emperor Goose

Remains of the emperor goose were found in eleven cuttings, ranging in age from the most ancient (Sand Mound—ca. 1,500 years) to those of the Punuk-Thule period (ca. 1,000 years). Strangely enough, no bones were found in the excavations of more recent sites. This is essentially similar to the St. Lawrence Island record, where no bones were found in the oldest or the most recent cuts, but only in diggings at Kialegak and Seklowaghyaget, both of Pinuk-Thule age. In the St. Lawrence Island collection, there were no long bones, but chiefly metacarpals, clavicles, and coracoids; in the present series are humeri, ulnae, femurs, sacra, metatarsals, and metacarpals.

Anser albifrons (Scopoli): White-fronted Goose

The white-fronted goose is sparingly represented by bones found in six diggings of from 1,000 to 1,500 years antiquity. In all but one of these sites, only single bones were unearthed, in the one, there were two bones.

Anas platyrhynchos platyrhynchos Linnaeus: Common Mallard

Considering the total absence of bones of this species in the St. Lawrence Island material, it is surprising to find the mallard abundantly represented in the present collection. No fewer than 49 bones of this duck were unearthed in 24 diggings of all ages from most ancient to most recent.

Dafila acuta (Linnaeus): Pintail

Four cuttings of Punuk-Thule age yielded one bone each of this duck. It was even scarcer in the St Lawrence Island collection, where only a single bone was unearthed in a cut of comparable age.

Nyroca marila (Linnaeus): Greater Scaup Duck

Fifteen diggings yielded 25 bones of this duck (tibiotarsi, humeri, and ulnae).

Glaucionetta clangula (Linnaeus): Goldeneye

A few bones of this species were found in two cuttings of about 1,000 years of age. The subspecific identification is impossible even to guess at, as either the Asiatic or the American form might occur in the region.

Clangula hyemalis (Linnaeus): Oldsquaw

The oldsquaw is represented by 26 bones from 15 different diggings, all but one recent one of Punuk-Thule age. This is in agreement with the record of the species in the collection from St. Lawrence Island.

Polysticta stelleri (Pallas): Steller's Eider

Unlike the St. Lawrence Island material, where this duck was poorly represented, the present collection contains 30 bones from 20 sites. With two exceptions (both recent sites) all the diggings involved were of Punuk-Thule age. The number of bones varied from one to nine in any single site.

Somateria v-nigra Gray: Pacific Eider

The Pacific eider is very abundantly represented in the present collection, 107 bones from 35 diggings being identified as of this species. All ages, from 50 to 1,500 years, are presented in the cuttings involved.

Somateria spectabilis (Linnaeus): King Eider

The most abundant species in the collection, no less than 188 bones from 60 diggings being of this eider. These diggings cover the entire time range of from 50 to 1,500 years antiquity.

Melanitta deglandi (Bonaparte): White-winged Scoter

The white-winged scoter is represented by 18 bones from eight diggings, all of the Punuk-Thule period The bones include humeri, tibiotarsi, and sterna.

Oidemia americana Swainson: American Scoter

Eight bones of this duck were unearthed in four cuttings, two of which were of recent date and two of Punuk-Thule age.

Lagopus sp.: Ptarmigan

Eight bones (seven humeri and one metacarpal) from as many cuttings, all but one (recent) of Punuk-Thule age, are here recorded together. Probably two species, the rock ptarmigan, *Lagopus rupestris* subsp , and the Alaska ptarmigan, *Lagopus lagopus alascensis* Swarth, are represented, but it is not possible to identify them with absolute certainty.

Grus canadensis canadensis (Linnaeus): Little Brown Crane

Four diggings of the Punuk-Thule level revealed bones (one in each) of the little brown crane. The bones were a skull, two fragmentary tibiotarsi, and a tarsometatarsus.

Stercorarius pomarinus (Temminck)· Pomarine Jaeger

The absence of jaeger bones in this collection is noteworthy by contrast with their abundance in the St. Lawrence Island material Whereas in the latter collection, there were large numbers of bones of the long-tailed jaeger and a few remains of the parasitic jaeger, the Cape Prince of Wales excavation yielded only three tibiotarsi of the pomarine jaeger, all from one cutting of Punuk-Thule age.

Larus hyperboreus Gunnerus: Glaucous Gull

Eleven cuts of all ages from 50 to 1,500 years yielded bones (one in each case) of this large gull. The bones included metacarpals, humeri, mandibles, tarsometatarsi, and tibiotarsi.

Larus glaucescens Naumann: Glaucous-winged Gull

Bones of this gull were found in only two of the cuttings of Punuk-Thule age. The excavation at Eyumnik yielded two metacarpals and a femur; the other (cut 8), one tibiotarsus.

Larus argentatus subsp.: Herring Gull

The most abundantly represented gull. Twenty-five bones from 16 diggings are identified as of this species; the diggings covering the entire time range of from 50 to 1,500 years.

Rissa tridactyla pollicaris Ridgway: Pacific Kittiwake

In three diggings, one recent and two of Punuk-Thule age, were found bones of the Pacific kittiwake (one bone—a humerus, in each case).

Xema sabini (Sabine): Sabine's Gull

Sabine's gull is poorly represented in the collection, only two tibiotarsi being identified These came from two cuts of Punuk-Thule age.

Sterna paradisaea Brunnich: Arctic Tern

The Arctic tern is represented by a humerus and an ulna from a cutting of Punuk-Thule age. Judging by its absence in all the other cuttings, one may surmise that it was very infrequently eaten.

Uria spp.: Murres

Murres, probably of two species, *Uria lomvia arra* (Pallas) and *Uria aalge californica* (Bryant), are represented by 104 bones found in 38 cuttings of all ages from 50 to 1,500 years. The most striking contrast between the present collection and that from St Lawrence Island is the relative abundance of murre bones. In the latter, murre bones comprised a little more individual bones than all the other species combined; in the present collection, no such outstanding preponderance is true, in fact, murre bones are greatly outnumbered by king eider and also by Pacific eider. Undoubtedly, the reason for this is that on St. Lawrence Island, there are many cliffs where the murres nest, while in the Cape Prince of Wales area there are no such formations and hence murres are not only less numerous but also harder to catch than where they can be snared at the nest.

The greatest number of murre bones from any one digging is from the oldest site—Sand Mound near the Light House, where eleven humeri, one femur, two coracoids, two metacarpals, eight ulnae, and three tibiotarsi were unearthed; the next most productive cut, one of Punuk-Thule age, yielded one skull, two sterna, two pairs of mandibles, two synsacra, two humeri, two ulnae, one coracoid, and three tibiotarsi. In the cuts of recent age, the number of murre bones (where found) is from three to six. It follows that the Eskimos of Cape Prince of Wales did not feed on murres to anything like the extent that the St. Lawrence Islanders did.

Cepphus columba Pallas: Pigeon Guillemot

The pigeon guillemot is represented by nine bones (all femurs!) from three cuttings of Punuk-Thule age.

Cyclorrhynchus psittacula (Pallas): Paroquet Auklet

Three diggings, two of Punuk-Thule age, and one recent one, revealed bones (one in each case) of the paroquet auklet. This is in striking contrast to the abundance of remains of this species in the St. Lawrence Island collection.

Aethia cristatella (Pallas): Crested Auklet ·

Of this auklet, 47 bones were gathered from 27 different cuttings. While most of the bones were humeri, there were also sterna, coracoids, and clavicles.

Aethia pusilla (Pallas): Least Auklet

Fourteen diggings, all but one of Punuk-Thule age, and one recent one,

contained bones of the least auklet, 29 in all, including humeri, sterna, coracoids, and metacarpals.

Fratercula corniculata (Naumann): Horned Puffin

A single humerus from a cutting of Punuk-Thule age is the only bone of the horned puffin found in the collection. The scarcity of remains of this species and the next one may not necessarily indicate the numerical status of the two species in the area, as on St. Lawrence Island, "in spite of their abundance and size, neither of the puffins . . . seems to have figured very largely in the diet of the ancient Eskimos" (Journ. Washington Acad. Sci. 24: 96. 1934).

Lunda cirrhata (Pallas): Tufted Puffin

The tufted puffin is represented by five bones from two excavations of Punuk-Thule age.

Nyctea nyctea (Linnaeus): Snowy Owl

A single coracoid from a recent site (50–100 years old) is the only bone of this species in the collection As on St. Lawrence Island, owls may not have been looked upon as food.

Corvus corax principalis Ridgway: Northern Raven

Two raven bones, one from the oldest site (1,500 years) and one of Punuk-Thule age (1,000 years) are all that represent this bird. However, this is due not to the scarcity of the raven but to the taboos regarding killing it. Not a single raven bone was found in the refuse mounds on St. Lawrence Island, where the raven is a common bird.

ICHTHYOLOGY.—*The gobies* Waitea *and* Mahidolia.[1] HUGH M. SMITH, U. S. National Museum.

The two gobioid genera *Waitea* and *Mahidolia*, with a rather wide distribution in the Oriental and South Pacific regions (Philippine Islands, Samoan Islands, Java, and Thailand or Siam), have become somewhat involved in the literature, and it seems desirable, with the information and material now available, to attempt a clarification of their status. These genera are similar in possessing a pronounced backward extension of the jaws, but their general appearance is different and taxonomically they are quite distinct.

Genus Waitea Jordan and Seale

Jordan and Seale (1906) established *Waitea* as a new genus of gobies and indicated *Gobius mystacinus* Cuvier and Valenciennes (1837) as the genotype. No description of the genus was given except that it was close to *Gobionellus* but had the maxillaries produced backward as in *Opisthognathus*. Beyond the mere listing of *Waitea mystacina* (Cuvier and Valenciennes) as being known from Samoa and Java,

there was no reference to any specimens taken in Samoan waters, although there was published a text figure from a drawing presumably made from a Samoan specimen. It is not a matter of record that the authors of *Waitea* compared their Samoan fish with any authentic specimen of *Gobius mystacinus*.

The first definition of the genus *Waitea* seems to have been given by Herre (1927) and was based on Jordan and Seale, reinforced by the information afforded by specimens from the Philippine Islands. Herre identified these fish as *Waitea mystacina;* and while his description was in some particulars considerably at variance with specimens from the Philippines and Samoa in the U. S. National Museum, Herre considered his specimens "unmistakably the same fish as shown in Jordan and Seale's figure."

The description and discussion of the genus *Waitea* given by Koumans (1931) were most unsatisfactory because his conclusions were based largely on the examination of two specimens in the Paris Museum collected in Java by Kuhl and van Hasselt and labeled *Gobius mystacinus* which were subsequently found by Koumans to represent *Oxyurichthys microlepis* (Bleeker). Koumans later examined the undoubted type of *Gobius mystacinus* in the Paris Museum but in trying (1935) to reconcile that type with *Waitea mystacina* of Jordan and Seale of which he had seen no specimens he ran into further difficulties and concluded his consideration of *Waitea* and *Waitea mystacina* in these words:

> The figure of *Waitea mystacina* (C & V) published by Jordan & Seale (Bull Bur Fish xxv, 1905, p 407, fig 94) differs from the type specimen in Paris Museum in several respects. The anal fin shows I 11 rays instead of I 9 in the type specimen; in the figure the 5th ray of D I is the longest, in the type specimen the first ray is the longest, the other rays decrease gradually in length. The shape of the caudal is not lanceolate in the type specimen, but much shorter, and finally the pattern of coloration is a totally other one. So I am not quite certain that Jordan & Seale had the real *Gobius mystacinus* in hands and therefore the locality Samoa is uncertain

The U. S. National Museum contains a specimen of *Waitea* collected at Apia, Samoan Islands, by Jordan and Kellogg in 1902, which is without doubt the same fish as figured by Jordan and Seale from a drawing by W. S. Atkinson.

From a critical examination of this specimen it is clear that the fish that Jordan and Seale identified as *Gobius mystacinus* of Cuvier and Valenciennes and made the type of their genus *Waitea* is not the fish that Cuvier and Valenciennes so designated. While there is a certain similarity, the differences are so marked and fundamental

that the two fishes can not be regarded as conspecific or even congeneric.

In this case, of which there are numerous parallels in the annals of zoological nomenclature, a new genus has been assigned a genotype that is assumed to be identical with and is given the name of an existing species that, in fact, is not the same as the particular fish in hand.

The question arises (*a*) whether the old specific name *mystacinus* together with the species it had hitherto represented goes with the new genus for which it had been mistakenly designated as the type, or (*b*) whether the fish incorrectly identified as *Gobius mystacinus* should receive a new specific name. The latter course seems preferable and will here be followed, although the International Rules of Zoological Nomenclature do not appear to provide the means for a definite decision. The Opinion of the International Commission on Zoological Nomenclature that bears most directly is No. 65, dealing with cases in which a genus is based upon erroneously determined species. Out of a very voluminous correspondence and protracted discussion there was evolved the opinion "that as a specimen is the type of a species, so a species is the type of a genus, and hence when an author names a particular species as type of a new genus it is to be assumed that it has been correctly determined. If a case should present itself in which it appears that an author has based his genus upon certain definite specimens rather than upon a species it should be submitted to the Commission for consideration."

In view of the impracticability of invoking the opinion of the Commission at this time and in view of the manifest impropriety of making *Gobius mystacinus* Cuvier and Valenciennes the genotype of *Waitea* on the basis of a specimen of another species incorrectly so identified, it is herein proposed to recognize and validate the genus *Waitea* as having as its genotype the particular and only species that Jordan and Seale had before them when they established the genus. This species has been heretofore unnamed and is here described as new from specimens in the U. S. National Museum.

Waitea stomias, new species (Gobiidae)

Waitea mystacina (Cuvier and Valenciennes) Jordan and Seale, 1906, p. 407, fig. 94; Samoa. (Not *Gobius mystacinus* Cuvier and Valenciennes.)
Waitea mystacina (Cuvier and Valenciennes) Jordan and Richardson, 1908, p. 279; Luzon, Philippine Islands. (Not *Gobius mystacinus* Cuvier and Valenciennes.)
Waitea mystacina (Cuvier and Valenciennes) Herre, 1927, p. 208; Panay, Philippine Islands. (Not *Gobius mystacinus* Cuvier and Valenciennes.)

Wailea mystacina (Cuvier and Valenciennes) Koumans, 1935, p. 133;
    (*Gobius mystacinus* Cuvier and Valenciennes, in part.)

Description.—Elongate; body rather strongly compressed, its depth 4.8
in standard length; caudal peduncle rather slender, its least depth 2 times
in depth of body, 3 in length of head, and 1.75 in its own length; head large,
moderately compressed, its length 3.2 in standard length, its width 2 in its
length and 0.8 its depth; snout 2.75 in head, rather strongly decurved; eye 1.6
in snout, 4.5 in head; interorbital space narrow, less than 0.5 eye; mouth
large, slightly oblique, upper lip broad; maxillary extending to posterior
edge of preopercle, 1.4 in head and as long as head less snout; teeth in each
jaw in a narrow band of about four rows, the outer row enlarged; tip of
tongue obtusely rounded; gill openings restricted, extending forward under
middle of opercle, the isthmus somewhat wider than the eye.

Squamation: Scales weakly ctenoid, 27 in longitudinal series, 7 or 8 in
transverse series, 12 circumpeduncular; nape, predorsal area, opercles,
check, breast, and base of pectoral naked.

Fins: Dorsal rays VI-I,10; dorsal spines long, flexible, increasing in
length from first to fifth, fifth as long as head; interdorsal space short, 0.3
eye; second dorsal base as long as head, the posterior rays reaching on
caudal when depressed; caudal fin lanceolate, 1 5 times head and 0.5 com-
bined length of head and body; anal similar to second dorsal, rays I,11;
ventral fin long, reaching to anal; pectoral pointed, extending to opposite
second branched ray of dorsal and anal fins, pectoral rays 19.

Coloration: Midside of body with five roundish black areas larger than
eye, the last at base of caudal fin; back and side with small roundish black
or dark brown spots in irregular disposition, top of head mottled with dark
brown; rays of both dorsal fins with small black spots which form into irregu-
lar transverse lines; caudal with six broad, curved, dark cross bands; anal
dusky; ventrals purplish black, pectorals plain.

Type —The type, 7.4 cm in total length, was collected by Jordan and
Kellogg in 1902 at Apia, on Upolu, one of the Samoan Islands. U.S.N.M.
no. 51816.

Other specimens.—The U. S. National Museum contains two other speci-
mens (nos 99295 and 99296) taken in 1909 by an *Albatross* party in the Agus
River near Camp Overton, Mindanao, Philippine Islands These specimens,
6.7 and 6 5 cm long, agree very closely with the type in form and color, but
have an increased number of scales in longitudinal series (29 and 31) and
show some variation in the dentition, with the inner row of teeth in the
upper jaw enlarged and with an anterior patch of teeth in the lower jaw
curved canines.

Remarks. --As already indicated, this is the fish that Jordan and Seale
misidentified as *Gobius mystacinus* of Cuvier and Valenciennes and made the
genotype of *Wailea*.

Wailea stomias, as represented by the type from Samoa and the two speci-
mens from Mindanao in the national collection, can not be the same species
that Herre (1927) called *Wailea mystacina* and considered "unmistakably"
represented in Jordan and Seale's figure To show that Herre's two speci-
mens 45 and 46 mm long from Iloilo are different it is necessary only to note

that the scales in longitudinal series are given by Herre as 36 or 38 (as against 27 in *stomias*), the scales in transverse series are stated to be about 16 (against 7 or 8 in *stomias*), the branched anal rays are given as 9 (against 11), and the shape of the first dorsal and caudal fins is entirely dissimilar.

Genus **Mahidolia** H. M. Smith

The genus *Mahidolia* was proposed by H. M. Smith (1932) for the accommodation of a Siamese estuarine goby thought to be new and given the name *normani* by Smith and Koumans in honor of J. R. Norman, of the British Museum. Several years later Koumans (1935), having examined the type of Cuvier and Valenciennes' *Gobius mystacinus* in the Paris Museum, concluded that *normani* from Siam is identical with *mystacinus* from Java. While accepting this conclusion I dissent from Koumans' various contentions (1) that *Mahidolia* is a synonym of *Waitea*, (2) that *Mahidolia normani* is identical with *Waitea mystacina* of Jordan and Seale, and (3) that the name *Waitea mystacina* of Jordan and Seale represents the same fish that Cuvier and Valenciennes called *Gobius mystacinus*.

It is remarkable that with all the revising that has been accorded the multicomposite genus *Gobius* (Linnaeus, 1758), the species *Gobius mystacinus* dating from 1837 should have remained untouched until a comparatively recent date and even then, in my opinion, should have been incorrectly allocated. As long ago as 1861 Günther said of *Gobius mystacinus* that "this species appears to be the type of a separate genus."

The proper name and synonymy of the genotype of *Mahidolia* are as follows:

Mahidolia mystacina (Cuvier and Valenciennes)

Gobius mystacinus Cuvier and Valenciennes, 1837, p. 124.—Günther, 1861, p. 48.
Waitea mystacina Herre, 1927, p. 208; in part.—Koumans, 1931, p. 67, in part; 1935, p 133, in part.
Mahidolia normani Smith and Koumans, 1932, p. 256, pl. 23, fig. 1.

COMPARISON OF WAITEA AND MAHIDOLIA

In view of the uncertainty that has arisen with regard to the distinctness of *Waitea* and *Mahidolia*, there are presented comparisons of certain features in the two genera, and there are shown outline figures of the genotypes. These figures alone are conclusive evidence that *Waitea stomias* (= *Waitea mystacina* of Jordan and Seale and of Koumans) can not as claimed be the same fish as *Gobius mystacinus* of Cuvier and Valenciennes.

The squamation in described members of the two genera is quite different. In both the body is covered with weakly ctenoid scales and the head is scaleless, but in *Wailea* the breast is naked and in *Mahidolia* it is fully scaled. The scales in longitudinal series number 27 in *Wailea stomias* from Samoa but in specimens from the Philippines there are several more scales in that series; in transverse series the scales are 7 or 8. In *Mahidolia* from Siam the scales in longitudinal series number 40 to 45 and in transverse series 14 to 16.
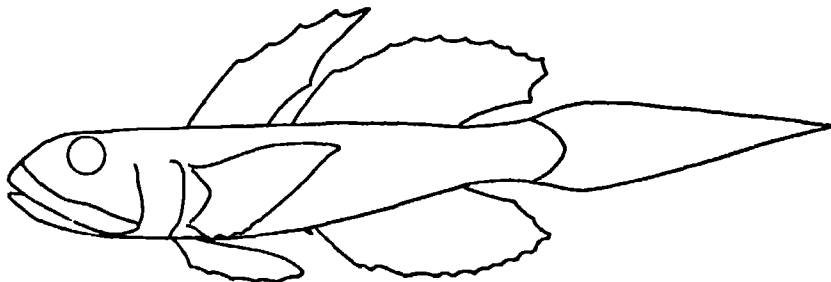
Fig 1 —*Wailea stomias*, new species: The type specimen, from Samoa Length, 7 4 cm
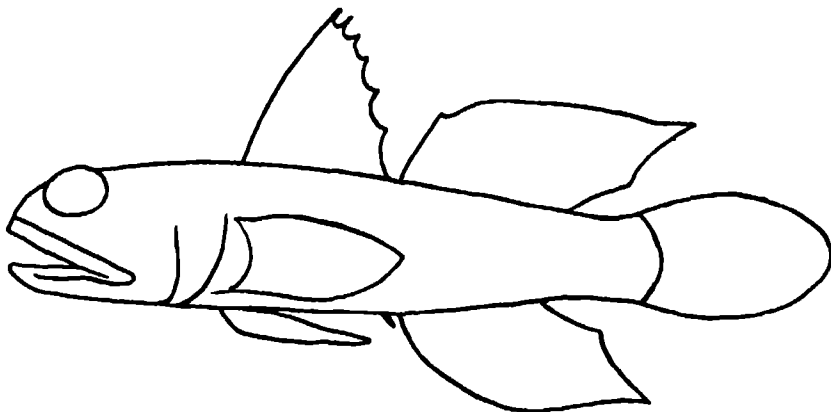
Fig 2.—*Mahidolia mystacina* (Cuvier and Valenciennes). The type specimen of *M normani*, from Siam Length, 6.2 cm.

The dentition is not markedly different in the two genera. The teeth in both jaws are in about four rows, with the median teeth minute. In *Wailea* the outer row of teeth in both jaws are enlarged and approach caninoid, and the inner teeth in the upper jaw may be slightly enlarged or small. In *Mahidolia* only the outer teeth in both jaws are somewhat enlarged.

The size of the gill openings is another point of difference. In *Wailea* these are quite restricted, extending forward to a point oppo-

site the base of the ventral fins; and the isthmus is correspondingly wide. In *Mahidolia* the gill openings extend well forward to a point under the anterior margin of the preopercle, or about half the distance between the posterior edge of the opercle and the eye; and the isthmus is correspondingly narrow.

As regards the fins, there are entirely different types of spinous dorsal and caudal fins in the two genera. In *Waitea* the length of the spinous rays *increases* gradually from the first to the fifth, the sixth being the shortest. In *Mahidolia* the length of the spinous rays *decreases* gradually from the first to the sixth. The caudal fin in *Waitea* is very long, lanceolate, and sharp-pointed; its length is half the combined length of head and body. The caudal fin in *Mahidolia* is obtusely rounded, its depth two-thirds its length, and its length less than one-third the combined length of head and body.

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MYCOLOGY.—*Descriptions of* Elsinoe dolichi, *n. sp., and* Sphaceloma ricini, *n. sp.*[1]   ANNA E. JENKINS, U. S. Department of Agriculture, Washington, D.C., and C. C. CHEO, National Tsing-hua University, Kunming, China.

Descriptions of two new species of Myriangiales are contained in an unpublished paper by Cheo and Jenkins.[2] The first is a species of *Elsinoë* on hyacinth bean (*Dolichos lablab* L.) for which the name *E. dolichi* is proposed. The other is on castor bean (*Ricinus communis* L.), and this is described under the name of *Sphaceloma ricini*. Both species were under study by the senior author when they were discovered in China, as explained in the paper. The first one had also been studied cooperatively with A. A. Bitancourt, of the Instituto Biologico, São

Paulo, Brazil. Because of the unavoidable delay that will be occasioned necessarily in the publication of the complete article, the Latin diagnosis[*] of the two new species is made available here as follows:

Elsinoë dolichi Jenkins, Bitancourt, and Cheo, n. sp.

Maculae in foliis interdum in superficie sola primo infecta distinctae, pallide alutaceae, interdum castaneo-marginatae, saepe margine elevatae, plus minusve nervisequentes, aliquando per laminam contiguam leniter extensae, saepe orbiculares, usque 4 mm in diam., cancri in petiolis caulibusque ex orbicularibus ellipticales vel elongati, minuti usque 1 cm longi, 3 mm lati, plani vel depressuli, saepe margine elevati, pallidi, interdum flavido-vel prominenter atro-purpureo-marginati, in siliquis plus minusve orbiculares punctati usque circa 5 mm in diam., generaliter brunnei vel purpureo-brunnei vel centro pallescentes; ascomata amphigena, in superficie primo infecta abundiora e sub cortice fusco superficiali oriunda, e massis pseudostromaticis ex hyalinis flavidulis composita, plerumque pulvinata, saepe erumpenia, aliquando fere superficialia, 60–300μ in diam., usque 100μ lata, saepe coalescentia vel saltem propinqua; asci inspersi, in stratis uno vel pluribus, immaturi subglobosi usqua pyriformes vel ellipsoidei, 20–32μ alti, 15–22μ lati, in maturitate probabiliter majores, ascosporae immaturae, 1–3 septatae, hyalinae, 7–13μ longae, 3–5 2μ latae conidiophora superficiem corticis fuscae plus minusve continenter tegentia, paulo abrupte attenuata, 10μ alta, basi 3.6–5 3μ lata; conidia in herba sparsa, elliptica, minuta usque 3 5 mm in diam., in culturis globosa, 2.5–3.5μ in diam., usque ellipsoidea, 3–4 6μ longa, 1 5–1.8μ lata, hyalina.

DISTRIBUTION: On leaves, stems, and pods of hyacinth bean (*Dolichos lablab* L.), causing the disease termed "scab of hyacinth bean," Kenya and Uganda, Africa, and Yunnan, China.

SPECIMENS EXAMINED. Serere, Uganda, Africa, September 17, 1930, D. C. Edwards. Type (Mycological Collections of the Bureau of Plant Industry, Washington, D C., no. 72652; Phytopathological Herbarium, Instituto Biologico, São Paulo, Brazil, no. 3267, and Imperial Mycological Institute, Kew, Surrey, England).

Yunnan, China, November 10, 1938, C. C. Cheo.

Sphaceloma ricini Jenkins and Cheo, n. sp.

Maculae in lamina foliorum plerumque e superficie superiore oriundas, orbiculares vel suborbiculares, papyraceas, saepe 2–3 mm in diam., in nervis subcontinuas, verruciformes, interdum per laminam contiguam extensas, in periolis caulibusque elliptico-elongatas, saepe utrinque aciminatas, primum rubro-brunneas, deinde luteas vel albas et brunneo-vel atropurpureo-marginatas producens; conidiophora in cancros conspicua, nunc in palum compactum flavidulum vel succineum, interdum partem centralem maculae tegentem, nunc separata vel sola, subuliformia vel cylindrica, plerumque simplicia, continua vel uniseptata, ex hyalinia usque flavidula, 10–30μ longa, 3–5μ lata, glabra vel e generatio acropleurogena conidiorum apiculata, breviter vel longe acuminata; conidia in forma, magnitudine coloreque varia-

bilia, plerumque oblonga, ovoidea, elliptica, e minuta (1–2μ) usque 10–15 longa, 2.5–4.5μ lata, minoria hyaline, majoria fusiformia, saepe flavidula.

DISTRIBUTION: On leaves and stems of castor bean (*Ricinus communis* L.), causing the disease termed "scab of castor bean," Taihoku, Formosa (Taiwan) and several localities in Yunnan, China.

SPECIMENS EXAMINED: Taihoku, Formosa, July 2 (type) (Mycological Collections of the Bureau of Plant Industry no. 72921) and August 1938, K. Sawada.

Ta-chong station, Yunnan, China, December 1938, T. F Yu, T H. Wang, and S. T. Chao; August 1939, C. C. Cheo; Gee-kai station, Yunnan, June 1939, C. C. Cheo.

PROCEEDINGS OF THE ACADEMY
AND AFFILIATED SOCIETIES

THE ACADEMY

368TH MEETING OF THE BOARD OF MANAGERS

The 368th meeting of the Board of Managers was held in the Library of the Cosmos Club on Friday, May 16, 1941. President CLARK called the meeting to order at 8:12 P.M., with 14 persons present as follows: A H CLARK, F. D ROSSINI, H. S. RAPPLEYE, W. W DIEHL, J. H HIBBEN, F C KRACEK, H. B COLLINS, JR , H E McCOMB, M. C. MERRILL, W. RAMBERG, J. R. CHRISTIE, C. L. GARNER, and by invitation, R J SEEGER

The minutes of the 367th meeting were read and approved

President CLARK announced the appointment of C. L. GARNER to continue as Chairman of the Committee on Meetings until June, 1942.

The Executive Committee, through the President and Secretary, reported on a meeting held by them on May 6, 1941, at which they received from the Committee to Survey the Academy's Investment and Deposits, H. S. RAPPLEYE (chairman) and A. T. McPHERSON, a report summarizing the present status of the Academy's investments and deposits and recommending that the savings account of nearly $8,500 be discontinued, since it was producing a return of only about 1 percent, and that the Academy place on deposit in investment accounts with two Federal Savings and Loan Associations, in which the principal amount of each account is insured up to $5,000, the sum of $8,500, with $4,500 in one and $4,000 in the other.

The Board authorized the Committee on Meetings to arrange for a meeting in September if they felt it desirable

The Committee on Membership, F. C. KRACEK, chairman, presented a nomination for membership for one resident person.

The Board considered individually and duly elected to membership the seven persons (six resident and one nonresident) whose nominations had been presented on March 14, 1941.

The Committee to Publish the Directory for 1941 reported that plans were under way to publish the Directory in accordance with the recommendations made by the Board at its previous meeting.

The Secretary presented the following information concerning changes in membership: Deaths, 2; acceptances to membership, 5, qualified for membership, 9 (resident); retirements, none; resignations, none. The status of the membership as of March 15, 1941, is as follows:

	Regular	Retired	Honorary	Patrons	Total
Resident.	428	35	3	0	466
Nonresident	128	15	14	3	160
Total ..	556	50	17	3	626

In accordance with instructions from the Board in January, the Board of Editors presented a report, through R. J. SEEGER, Acting Senior Editor, concerning their study of the desirability of changing the Journal to a 2-column format and recommended that such a change be made, as it would bring about an annual saving of about $200. The Board passed a resolution instructing the Board of Editors to issue the Journal with a 2-column format beginning with the first number of the 32d volume, in January, 1942.

The Board instructed the President to appoint a delegate to represent the Academy at the 175th anniversary celebration of Rutgers University, October 9, 10, and 11, 1941

President CLARK addressed the Board on the subject of giving serious thought to the possible ways in which the Academy might better fulfill its obligations as the leader of science in Washington, and asked each member of the Board to consider this problem and to make appropriate recommendations at the first meeting of the Board in the fall.

The meeting adjourned at 9:33 P.M

FREDERICK D. ROSSINI, *Secretary*

CHEMICAL SOCIETY

528TH MEETING

The 528th meeting (57th annual meeting) was held in the auditorium of the Cosmos Club on Thursday, January 9, 1941, at 8:15 P M , President HALLER presiding. The annual reports of the officers and committee chairmen for 1940 were read and approved. Dr. WILLIAM J. SVIRBELY was elected Councilor to fill the office vacated by the resignation of Dr G. E. F. LUNDELL, who had recently been elected to the office of Councilor-at-Large in the National Society. The Society was addressed by the retiring-president, Dr. RAYMOND M. HANN, who spoke on the subject *Some observations on the Walden inversion in the sugar series.*

529TH MEETING

The 529th meeting was held in the Auditorium of the Cosmos Club on Thursday, February 13, 1941, at 8:15 P.M., President HALLER presiding It was announced that Dr. F. G. BRICKWEDDE, of the National Bureau of Standards, was to be awarded the Hillebrand Prize for 1940 for his outstanding work on deuterium and its compounds. The Society was addressed by Prof. WILLIAM MANSFIELD CLARK, of the Department of Physiological Chemistry, Johns Hopkins University, who spoke on the subject *Metalloporphyrins.*

530TH MEETING

The 530th meeting was held in the Auditorium of the Cosmos Club on Thursday, March 13, 1941, at 6:30 P.M. The occasion was the annual banquet of the Society at which about 110 members and guests were present to celebrate the awarding of the Hillebrand Prize to Dr. F. G. BRICKWEDDE, of the National Bureau of Standards, for his excellent work on deuterium and its compounds, with special reference to the preparation and determination

of properties of hydrogen deuteride President HALLER acted as toastmaster Dr. HANN spoke a few words on the work of Dr. BRICKWEDDE. The speaker of the evening was Prof. H. C. UREY, of Columbia University, who spoke on the differences in the Raman spectra of the isotopic deutero modification of methane. Professor UREY in his talk praised the work of Dr. BRICKWEDDE and considered him well worthy of the award which he had received.

531ST MEETING

The 531st meeting was held in the Auditorium of the Cosmos Club on Thursday, April 3, 1941, at 8:15 P.M., President HALLER presiding. Following the routine business, the Society was addressed by Dr W ALFRED LA LANDE, JR., director of research, Attapulgus Clay Co., who spoke on the subject *Some industrial applications of mineral adsorbents.*

532D MEETING

The 532d meeting was held jointly with the Washington Chapter of the American Institute of Chemists in the auditorium of the Cosmos Club on Thursday, April 10, 1941, at 8:15 P.M. In the absence of President HALLER, Secretary BEKKEDAHL acted as Chairman After a few words by Dr. A. H WARTH, chairman of the Washington Chapter of the American Institute of Chemists, and by F. O. LUNDSTROM, Chairman of the Washington local cooperating committee of the Chemist Advisory Council, the Society was addressed by FRANK G. BREYER, of Singmaster and Breyer, consulting metallurgists and chemical engineers of New York City, who is a member of the Board of Directors of the Chemist Advisory Council, Inc. He spoke on the subject *The activities of the Chemist Advisory Council, Inc.* Mr. BHAGWAT, Secretary of the Council, also spoke briefly on the organization and accomplishments of the Council

533D MEETING

The 533d meeting was held at the University of Maryland, College Park, Md., on Thursday, May 8, 1941. A dinner was held in the University Dining Hall at 6:30 P.M At 8:15 P.M., the general meeting took place in Room A-1 of the Arts and Science Building, President HALLER presiding. Following the completion of routine business, the following communications were presented in four sections:

Biochemistry, DR M HARRIS, *presiding*

HUGO BAUER, National Institute of Health. *Synthesis of organic phosphorus compounds of interest in chemotherapy.*

SANFORD M. ROSENTHAL, National Institute of Health: *Some relations of structure and pharmacological behavior to chemotherapeutic action*

J. P. GREENSTEIN and ALEXANDER HOLLAENDER, National Institute of Health: *Physical changes in thymonucleic acid induced by salts, proteins, and ultraviolet irradiation.*

L. A. SHINN and B H. NICOLET, Bureau of Dairy Industry: *Determination of methylpentoses in the presence of pentoses*

Inorganic and Analytical Chemistry, DR C E WHITE, *presiding*

CLEMENT J. RODDEN, National Bureau of Standards: *Spectrophotometric determination of praseodymium, neodymium, and samarium*

HUBERT W. LAKIN, Division of Soil Chemistry and Physics, U. S. De-

partment of Agriculture: *Selenium in pyritic mine slimes as a potential agricultural hazard.*

A. GEORGE STERN, U. S. Bureau of Mines: *Fluorescent lighting—its mineral chemistry and dramatic uses.*

Organic Chemistry, DR R. P. JACOBSEN, *presiding*

W. T. HASKINS, RAYMOND M. HANN, and C. S. HUDSON, National Institute of Health: *A synthesis of the epimer of cellobiose.*

F. B. LAFORGE and S. F. ACREE, JR., Bureau of Entomology and Plant Quarantine: *The reaction of some allenes with lead tetracetate.*

J. R. SPIES, Bureau of Agricultural Chemistry and Engineering: *The chemistry of cottonseed allergens.*

Physical Chemistry, DR F O RICE, *presiding*

B. J. MAIR, A. R. GLASGOW, JR., and F. D ROSSINI, National Bureau of Standards: *Separation of hydrocarbons by azeotropic distillation.*

A. L. SKLAR, Catholic University of America: *Mechanism of auxochrome effects.*

534TH MEETING

The 534th meeting was held in the auditorium of the Chemistry Building of the Catholic University of America on Thursday, May 22, 1941, at 8:15 P M , President HALLER presiding Following the routine business, the Society was addressed by Prof. PETER DEBYE, Head of the Department of Chemistry, Cornell University, Ithaca, N. Y , who spoke on the subject *Analysis of molecular structure by electron scattering.*

NORMAN BEKKEDAHL, *Secretary.*

MATHEMATICS.—*Intuitive and descriptive geometry of function space: The graphical representation of geometrical figures.*[1] Merle Randall, Department of Chemistry, University of California, and Bruce Longtin, Department of Chemistry, Illinois Institute of Technology. (Communicated by Frederick D. Rossini.)

Beginning with the monumental works of Volterra[2] and Hilbert,[3] the theory of functionals and their calculus has rapidly become an extremely important field of mathematics. More particularly is this true because of the wide field of practical applications that this theory is finding in physics, engineering, biophysics, economics, and other social sciences.

From the viewpoint of one of its fundamental methods of attack (evident in the works of both Hilbert and Volterra), the theory of functionals takes as its field the mathematical relationships that are expressible in terms of spaces of an infinite number of dimensions and that depend simultaneously upon at least a finite fraction of the total number of dimensions.

The theory of functionals is thus intimately connected with the geometry of spaces of n dimensions, n being indefinitely large. However, in accordance with an early statement of Hadamard[4] that the intuitive processes of geometry are completely denied in this field, the indeed fruitful geometric reasoning so far applied to the theory of functionals has been almost without exception abstract and analytic in nature.

It is the purpose of this paper to present and give applications of a graphical representation by means of which some measure of purely geometrical intuition may be rescued to the field of functional theory.

At the same time it will be seen that the representation is of somewhat wider application. Obviously, no geometric intuition can be complete for spaces of more than a limited number of dimensions. The method must lean heavily on abstract analysis.[5] Thus demonstrations that have already been repeated many times in the history of functional theory must be called upon again in order to develop fully the limited range of possible intuitions. Of these the method of passage from a finite to an infinite number of dimensions will be used most frequently.

REPRESENTATION OF n DIMENSIONS IN A SPACE OF m DIMENSIONS

The representation of 3-dimensional figures by means of plan and elevation views is quite familiar and commonplace. A number of writers[6] have used similar methods to represent 4- and 5-dimensional figures either in two dimensions or by means of solid models. In general, whether projective or other methods are used, a single point in n dimensions may be represented by means of a sufficient number of points in m dimensions, and an n-dimensional figure by a sufficient number of m-dimensional "views."

A point in n dimensions is determined uniquely by exactly n parameters. A point in m dimensions is therefore sufficient to represent m parameters. If an n-dimensional point is restrained to lie in an m-dimentional locus of any nature, it is only capable of representing m rather than n parameters, and hence (so far as representation is concerned) is effectively only the m/n^{th} part of an n-dimensional point. Thus a point that lies in a surface in three dimensions has only two degrees of freedom and is effectively only two-thirds of a 3-dimensional point.

In order to represent an n-dimensional point in m dimensions at least n/m points will be needed. Each point will represent m dimensions and n/m of them will represent $(n/m)m$ or n dimensions. Thus to represent 3-space on drawing paper requires $1\frac{1}{2}$ points (i.e., a point and another point confined to a line or curve). In the plan and elevation views the plan point determines a vertical locus along which the elevation and the vertical coordinate of the elevation view point represent the 3-space coordinates of the point. In the Cavalier projection

[5] See LENZEN, Amer. Math. Monthly 46: 324.   1939.
[6] JOUFFRET, E P.   Mélanges de géométrie à quatre dimensions, Paris, 1906
MANNING, H P   Geometry of four dimensions, Macmillan, New York, 1914.
SCHOUTE, P. H   Mehrdimensionale Geometrie, Leipzig, 1902, 1905.
SOMMERVILLE, D. M. Y.   An introduction to the geometry of n dimensions, London, 1929
VERONESE, G   Fondamenti di geometria (pt 2), Padova Tipografia del Seminaria, 1891.

commonly used by analytical geometers, a plan view point is shown in oblique XY coordinates, and a point is given on the vertical ray through the plan view point, which gives the principal view of the projection. Either of these representations alone is sufficient. However, both together offer a far richer intuition as to the space geometry of the figure represented. The addition of auxiliary views will further increase the richness of the representation.
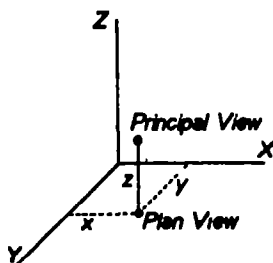
Fig. 1 —Representation of a point in Cavalier projection

To represent a 4-dimensional figure by solid models requires at least two models in one of which only one parameter of each point is independent of the three coordinates of the corresponding point in the other model. To represent the figure in two dimensions requires two completely independent views, or a number of dependent views. To represent an n dimensional figure requires $n/3$ independent solid models, or $n/2$ independent plane views. As n approaches infinity one can imagine the necessity of a shelf of models extending further and further indefinitely, or even of a book of drawings growing larger until it becomes volumes, stacks, and libraries without end.

While the complete representation by means of 2- or 3-dimensional diagrams becomes impractical for spaces of many dimensions, the representation by means of 1-dimensional diagrams does not. The necessary n 1-dimensional figures can be drawn on n parallel lines. As n increases, the lines may be crowded together, so that they always remain on a single sheet of paper.

Such a representation will, of course, be less rich than representation by means of models and 2-dimensional diagrams. However, it is a complete representation, and any desired 2- or 3-dimensional view may be obtained from it by the proper constructions. For example, any two of the 1-dimensional diagrams will serve to define values of two parameters of the n-dimensional point. These two values plotted as Cartesian coordinates will define a point which is one 2-dimensional view of the n-dimensional point.

THE PRINCIPAL REPRESENTATION

The proposed representation is simply a geometrical interpretation of the analytic results common in the theory of functionals. It gives rise quite naturally to essentially vector forms, whether the approach is vectorial or algebraic. From the point of view of the geometrical intuitions which may result, a vectorial approach is therefore desirable at the outset.
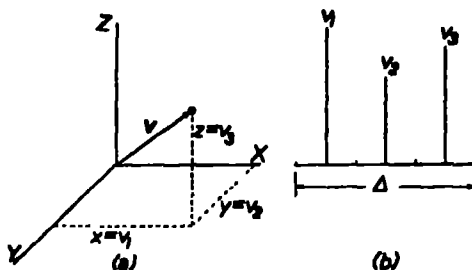
Fig 2 —A 3-dimensional radius vector in (a) Cavalier; (b) proposed projection

In Fig. 2 a 3-dimensional radius vector is represented both in Cavalier projection and by the proposed method. The components v_1 v_2, and v_3, of the vector v with respect to the given coordinate axes, are the three Cartesian coordinates x, y, and z, respectively, of the point represented by the head of the vector. In the proposed representation a horizontal interval, Δ, is divided into three equal segments, and the component v_1 erected at the center of the first segment, v_2 at the center of the second, and v_3 at the center of the third.

To represent a 4-dimensional radius vector whose components are (v_1, v_2, v_3, v_4), the same interval, Δ, would be divided into four equal segments and each of the four components erected at the center of one of the segments in the order named. To represent a space of n dimensions, the interval Δ is divided into n equal segments and each of the components v_i is erected at the center of one of the segments, in the order of increasing indices i. When any particular stage of subdivision of the interval Δ has been reached, the i^{th} component will be found at a position whose x-coordinate is $(a+(i/n)\Delta)$. If we wish, rather than designate it as v_i, we may designate it as $v(x)$, x serving the same purpose here as the index i.

It will be convenient to join the upper extremities of the strokes representing the components $v(x)$ by a broken line (Fig. 3), which serves to tie together the various points used in representing the same n-dimensional point. It is analogous to the projection ray used in de-

scriptive geometry to tie together several views of the same point. The only significant points on the line are those at the intersections of adjacent segments (i.e., the extremities of the vertical strokes).

If the indices i are so assigned that the components v_i are arranged monotonically in the order of increasing or decreasing magnitude (at least within finite subintervals of Δ) and the magnitudes are bounded, then as n approaches infinity the broken line representing the vector
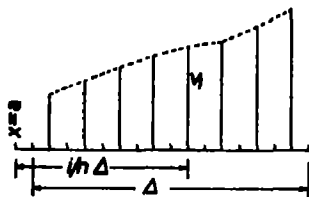
Fig 3 —Representation of an 8-dimensional radius vector

v will certainly approach as a limit a curve whose derivative is at least piecewise continuous. In this case $v(x)$ becomes in the limit a continuous or piecewise continuous function of x, provided it is in the limit defined for all values of x in Δ.[7]

For purposes of representation we shall assume that the vectors with which we deal are in general representable in the limit by continuous curves. Then we may describe the vector either geometrically by the curve $v(x)$, or analytically by a statement of the limiting function $v(x)$. We shall later see that such an assumption limits attention to a very narrow hypersolid angle in n-space. This limitation does not lead to any serious loss of generality, all the results being easily modified to fit vectors whose components show no correlation in magnitude with the arbitrary index i.

Because the representation of a point in space of an infinite number of dimensions by the method indicated leads to the most general picture of a function of x, such a space has come to be known as a function space. In particular when the geometry of the space is Euclidean, it is known as a Hilbert-space.

PRINCIPAL PROJECTIONS

The diagram representing a given n-vector may easily be projected on any of the subspaces defined by a group of the coordinate axes. For example in 3-space the projection of a point onto the XY plane, made

[7] If the number n is only so great that the group of points for which $v(x)$ is defined is of measure zero, then $v(x)$ will not be continuous, but all of its values will be values of a continuous or piecewise continuous function.

by rays parallel to the Z axis, is a point in the XY plane that has the same x- and y-coordinates as the given point, but whose z-coordinate is zero. In general, one of these *principal projections* may be obtained by discarding the coordinates v, corresponding to the axes x, parallel to which the projection rays are to be taken.

Expressed differently, a principal projection may be obtained by selecting the components corresponding to the particular projection-
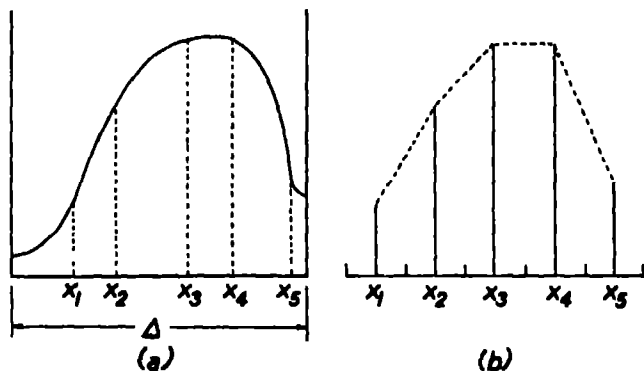
Fig 4 —(a) A point in ∞-space; (b) its principal projection on the x_1-x_2-x_3-x_4-x_5 hyperplane

hyperplane and constructing a separate diagram from these components.

In Fig. 4 the projection of a point in a function space onto the coordinate 5-plane defined by the x_1, x_2, x_3, x_4, and x_5 axes is shown. If the projection is made onto a coordinate plane or onto a coordinate 3-space, it may be *developed*, by plotting the two or three components as Cartesian coordinates. Such developments of projections onto planes and 3-spaces will constitute the chief method in the descriptive geometry of n-space.

If a vector happens to lie on one of the coordinate n-planes for which n is finite, then all but a finite number of its components will vanish. The only remaining ones will be those lying in the particular coordinate n-plane. The projection of such a vector onto this coordinate n-plane will then be simply the normal representation of an n-component vector in n-space as defined by Figs. 2 and 3. Obviously the case of a finite number of dimensions is merely a special case of an infinite number.

ADDITION OF VECTORS

By the sum, $u + v$, of two vectors is understood the vector s, each of

whose components is the sum of the corresponding components of u and v. Thus if

$$s = u + v, \tag{1}$$

then

$$s_i = u_i + v_i; \; (i = 1, 2, 3, \quad m) \tag{2}$$

for all values of m. Passing to the limit, we find

$$s(x) = u(x) + v(x). \tag{3}$$
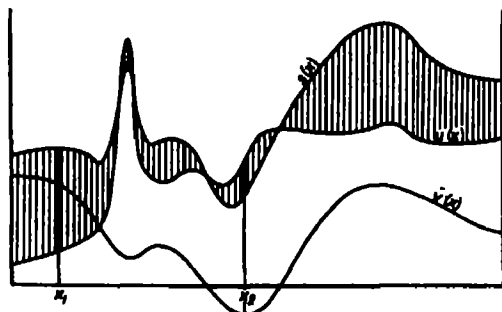
Fig. 5.—Graphical addition of vectors in function space

The graphical addition of the vectors $u(x)$ and $v(x)$ is shown in Fig. 5. Each of the ordinates of the curve $s(x)$ is the sum of the corresponding ordinates of the curves $u(x)$ and $v(x)$. The inverse operation of taking the difference, $s - u$, is also shown. The vertical rulings drawn between the curves $s(x)$ and $u(x)$ are each equal to the difference $(s_i - u_i)$ for some particular component. Hence they are corresponding ordinates of the curve $v(x)$ which represents the vector $(s - u)$.

The meaning of the construction of Fig. 5 may be made clearer by projecting the diagram onto the x_1-x_2 plane indicated by the cuts 1 and 2 in Fig. 5.

The developed projection is shown in Fig. 6. The vector v' which is equal to the vector v, corresponds to the shaded area of Fig. 5. In the projection the construction appears as the familiar addition of 2-dimensional vectors. The development of a 3-dimensional projection would similarly appear as an ordinary 3-dimensional vector addition. Analytically, no matter what components are selected for a projection, they will be connected by equations 2, which are the equations for vector addition in the resulting m-space.

FREE VECTORS

The vectors so far considered have been radius vectors (i.e., radiating from the origin). A free vector is one that may originate at any

point in space. Thus in Fig. 6 the vector $\mathbf{v}'$ is a free vector if the vector $\mathbf{u}$ may be varied at will.

In Fig. 5 the shaded area represents a free vector equal to $\mathbf{v}$ if the curve $u(x)$ may be arbitrarily varied. In general any free vector will be represented by the region between two curves (or broken lines in regions of space in which these do not approach smooth curves) in which
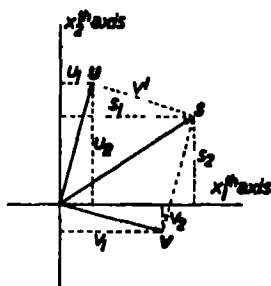
Fig. 6 —Principal projections of Fig 5 on the x_1-x_2 plane

the vertical distances between the curves represent the various components of the vector.

REPRESENTATION OF A STRAIGHT LINE

If a vector is prolonged along itself, one end remaining fixed, the other end will trace out a straight line. The prolonged vector is to be obtained by multiplying the vector by an arbitrary constant. Thus if the vector $\mathbf{l}_0$ is a radius vector to a particular point on the line, and $\mathbf{v}$ is any vector that lies along the line, then the radius vector $\mathbf{l}$ to any other point on the line is

$$\mathbf{l} = \mathbf{l}_0 + a\mathbf{v}, \tag{4}$$

where a is an arbitrary constant. This equation implies in detail that

$$l_i = l_{0i} + a v_i ; \quad (i = 1, 2, 3, \quad m) \tag{5}$$

for any value of m. In the limit for function space[8]

$$l(x) = l_0(x) + a v(x). \tag{6}$$

In Fig. 7,a the heavy curve represents the fixed point on the straight line. The vertical distances between the two full curves represents the vector $\mathbf{v}$. The upper dotted curve was obtained by adding twice the $v(x)$ ordinates to the $l_0(x)$ curve, and the lower one by subtracting half the $v(x)$ ordinate. Hence they represent the two points on the curve for which a is 2 and $-\frac{1}{2}$, respectively. Fig. 7,b is the

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[8] Cf FRÉCHET, M. *Essai de géométrie analytique à une infinité de coördonées,* Nouv. Ann Math (4) 5: 97, 289 1908.

developed projection of the construction onto the coordinate plane labeled x_1-x_2. This view shows the four points, l_0, (l_0+v), (l_0+2v) and $(l_0-\frac{1}{2}v)$ as lying on the same straight line. Any other projected view would likewise show them on the same straight line. Hence we may develop the intuition projectively that Fig. 7,a actually does represent a straight line.
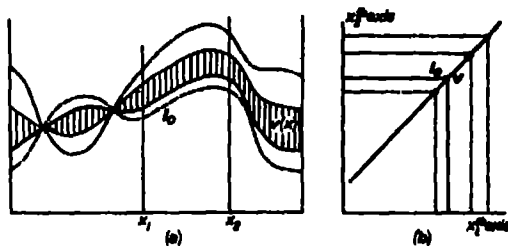
Fig 7 —(a) Representation of a line in function space; (b) its
principal projection on the x_1, x_2 plane

REPRESENTATION OF A PLANE[8]

Let u and v be two nonparallel vectors lying in a given plane, and let l_0 be the radius vector to a point in the plane. Then the radius vector, l, to any other point in the plane is given as

$$l = l_0 + av + bu. \tag{7}$$

In the limit of an infinite number of dimensions this becomes

$$l(x) = l_0(x) + av(x) + bu(x). \tag{8}$$

If b is kept constant and a allowed to vary, l will trace out a line on the plane. If b is then changed, l will trace out another line parallel to the first as a is allowed to vary. If b takes on all possible values, the whole plane is generated.

Fig. 8,a represents six different points lying in the same plane in a space of an infinite number of dimensions. These are the points for which a and b have the values (0, 0), (1, 0), (0, 1), (2, 0), (0, 2), and (2, 1), respectively. Fig. 8,b shows the developed projection of these points onto the x_1-x_2-x_3-coordinate 3-space. By choosing a particular value of b it is possible to make $l(x)$ vanish for $x=x_2$ for any value of a. When $l(x_2)$ is zero we obtain the series of points in the plane that in the developed projection of Fig. 8,b lie in the x_1-x_3-plane (component l = zero). By choosing b to make $l(x)$ vanish at $x=x_1$, and again at $x=x_0$, it is then possible to trace out the points on the plane that in the developed projection appear as the intersections of the plane with the three coordinate planes. This has been done. Thus the

developed projection of Fig. 8 shows the characteristics of a plane. By taking any number of such projections onto different coordinate 3-spaces, we soon develop the intuition that the construction of Fig. 8,*a* and equation 7 represents a plane in function space.

Because of the essential complexity of the representation, it is
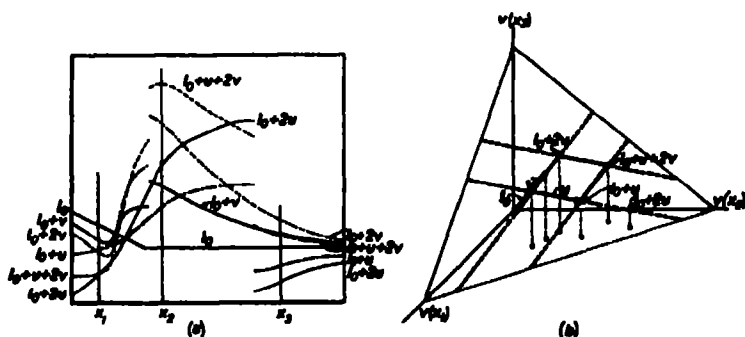
Fig 8 —(*a*) Representation of a plane in function space; (*b*) its principal projection on x_1, x_2, x_3-space

sufficient and convenient to represent a plane merely by specifying three points on it (e.g., the points l_0, $l_0 + u$, and $l_0 + v$ of Fig. 8).

REPRESENTATION OF A HYPERPLANE

Unless the hyperplane is so oriented that we see it edgewise, it can not be represented projectively in a 2- or 3-dimensional development. We will see later how limited portions may be represented by developed projections of their various 2- and 3-dimensional sections. For the convenient representation of an m-dimensional hyperplane we are therefore limited to the graphical specification of $(m+1)$ of its points, together with the direction that the general point is found as

$$l(x) = l_0(x) + \sum_0^m a_i u_i(x). \tag{9}$$

INTERSECTION OF TWO STRAIGHT LINES

Two straight lines need not intersect in function space. They will only intersect provided they lie in the same plane. If they do intersect, they must appear to intersect in the same point in all views. If they do not intersect, the apparent intersection will shift in going from one view to the next, owing to parallax.

The intersection, if any, of two lines may be determined by locating the apparent intersection in any single two dimensional view. This apparent intersection represents two points, one on each line, that appear one behind the other in the projection. Thus in Fig. 9,*b*, point *s* represents the apparent coincidence of these two points.

Returning to the original diagram Fig. 9,a, one may locate (by the method of Fig. 7) a complete view in function space of these two points. That is, a point on the line p_1p_2, and another on the line l_1l_2, may be located which have the x_1- and x_2-coordinates of the apparent intersection in the projected view. In the case shown, the two points
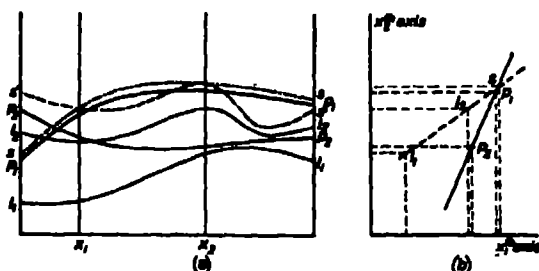
Fig 9 —Construction for locating intersection of two straight lines in function space.

that in the projection appear to coincide are not identical in the complete view, but are actually the two distinct points s and s'. If the lines actually do coincide, the two points that appear to coincide in the projection will be found to correspond to the same point in the complete view.

APPLICATIONS

Two applications of the methods so far developed in this paper are of importance. In representing the composition of mixtures of several chemical components phase diagrams are used that require as many dimensions as there are independent components.[9]

When the number of components is large or infinite, it becomes necessary to use the method of representation presented here. In studying processes for separating the components of a mixture, graphical methods based on the phase diagrams have been developed for binary and ternary mixtures. These methods may readily be generalized to multicomponent systems by translating them to the n-component vector diagram.

In studies of the intensity of illumination it is often important to consider the intensity of luminous energy concentrated in each wave length of a spectrum. These intensities may be considered as components of a vector in function space. The indices of the components very naturally become the wavelengths of the individual components of the spectrum. When two sources of light are combined additively, the resulting spectrum is to be found by adding their representative vectors.

[9] Cf RANDALL and LONGTIN   Journ Phys Chem 42: 1157   1938

ENTOMOLOGY.—*Some undescribed syrphid flies from the Neotropical region.*[1] FRANK M. HULL, University of Mississippi. (Communicated by EDWARD A. CHAPIN.)

I am indebted to Charles T. Greene, of the United States National Museum, for the privilege of studying a small but interesting collection of Neotropical syrphids. I also wish to thank Dr. E. A. Chapin, curator of insects, for many courtesies and facilities extended to me on visits to the Museum. All holotypes described in this paper except one are in the National Museum.

Mesogramma flava, n. sp.

Related to *tibicen* Wied ; black, with wide black frontal vitta, yellow face, humeri, and propleura; fourth abdominal segment with a median vitta and two pairs of yellow fasciae, which are characteristic

Female. Length 10 mm. *Head.* Vertex and front black, sides of the latter, its face, and cheeks reddish or brownish yellow. Antennae dark brown, the ventral portion of the third joint somewhat lighter. The pile of the antennae black. A considerable part of the upper occipital pile, as well as that of the front, black. *Thorax:* Black; narrowly separated pair of gray vittae in the middle of the mesonotum, the humeri and notopleurae, lateral margins, calli, and a broad marginal stripe on the scutellum yellow. Posterior part of mesopleurae, upper part of sternopleurae, and a large propleural spot yellow. *Abdomen:* With nearly parallel sides, black marked with yellow. Extreme corners of the first segment and a quite transverse complete band on the second segment just before the middle yellow. On the third segment there is a pair of slender, yellow, basal spots, narrowly separated in the middle, with their posterior margins rounded. There is also just before the middle of the segment a transverse band, slightly arcuate on either half and posteriorly indented in the middle On the fourth segment the middle band is broken into two spots, separated by a slender, yellow, median vitta, and there is a similar pair of slender basal spots almost touching the middle. On the fifth segment the slender basal fascialike spots on their outer ends merge into a pair of oblique yellow spots occupying the greater part of the center of the segment. *Legs.* Yellow; all the tarsi, the whole of the hind tibiae and of the hind femora, except the base, smoky brown with black pile. Pile of middle femora and tibiae and apical half of front femora chiefly blackish. *Wings:* Hyaline, the stigma brown.

Holotype: A female, from Restrepo, Colombia (J. Bequaert, collector); three paratypes in the U S National Museum (no. 55126) and two paratypes in the author's collection, all from the Upper Putamayo River, Colombia, B. Guegara, collector.

Mesogramma nasica, n. sp.

Related to *basilaris* Wied.; hind femora with only a subapical black annulus and extensively black pilose, front and face yellow, strongly projecting; first and second abdominal segments black, others pale.

Male. Length 6 mm. *Head:* Upper portion of occiput metallic, slightly brassy, with a prominent crease proceeding from the upper corner angles of

the eyes backward. Vertex behind the ocelli somewhat violaceous, the eyes touching for a distance of five or six facets, the vertical triangle rather narrow. Front and face yellow, the cheeks black, the face strongly protruding forward. Antennae pale brownish yellow, the third joint grayish brown on the dorsal and apical half. Arista dark brown to black. *Thorax:* Dorsum of thorax highly metallic, with a broad, light-brown, median, pollinose vitta, noticeable only from behind, underlying which the ground color is slightly bluish. Viewed from in front there is, upon each side of the median vitta, a broad obscure brownish stripe. Scutellum shining metallic black, the rim quite narrowly brownish but not yellow. Pleurae metallic black, the posterior half of the mesopleurae, a prominent spot on the upper part of the sternopleurae, and the humeri pale yellow. *Abdomen:* First and second segments polished shining black. There is a broad, oval, opaque black spot occupying the greater part of the center of the second segment, not reaching the sides or margins. The third, fourth, and fifth segments are dark shining red or brownish red. They are somewhat paler, broadly throughout the middle of the third and fourth segment, and narrowly and diffusely paler along the anterior half of the lateral margin of third, fourth and fifth segments There is a slender short pair of vittate spots in the middle of the third segment. Hypopygium shining black, sternum light brownish orange. *Legs:* First and second pairs of legs, excluding the coxae, light brownish yellow, their anterior tarsi brownish dorsally. Hind coxae, trochanters, and femora, except for a prominent subapical brownish black band, entirely light yellow. Hind tibiae dark brown throughout except for the narrow base. Hind tarsi entirely dark brown. *Wings:* Hyaline, faintly gray.

Holotype: A male, Tuxtepec, Oaxaca, Mexico, J. Camelo G., no. 1795 (U.S.N.M. No. 55127).

In shape this species is unusually flat, the sides of the abdomen are almost parallel, being slightly wider at the end of the second segment. It is characterized by its highly polished glassy appearance, margins of the mesonotum dark except the humeri, the black base, and red apex of the abdomen. The pile of the middle femora and tibiae, of the hind tibiae, and the apical half of the hind femora is black. The long black hairs of the hind femora occupy two-thirds of the length on the posterior side There are only a few scattered black hairs on the anterior femora.

Mesogramma azurlinea, n. sp.

Related to *taenia* Curran but without the median notches upon the abdominal fascia; face yellow and pointed; fifth abdominal segment with a median brown or black spot.

Male. Length 5.5 mm. *Head ·* Occiput along the sides pale grayish white, above ochre-yellow, without prominent grooves, the angles of the eyes truncate. For a short distance behind the ocelli the vertex is bright coppery with a violaceous tinge. Eyes touching for about five or six facets; front and face pale yellow, sides of the latter broadly whitish pubescent, the face produced only moderately, not protruding beyond the quite short, rounded, almost wholly orange antennae. On the third joint there is a faint brown tinge, not at all conspicuous. Arista dark brown. Only the posterior half of the cheeks is blackish. Mesonotum strongly yellowish-brown pollinose, with a prominent, narrow, blue, median line, which, viewed in front, is white-pollinose on the posterior half; also from in front there is submarginally or about the middle of each half of the mesonotum a somewhat obscure, yellowish, pollinose vitta. Lateral margins of the mesonotum including humeri and post-

calli brownish yellow. Scutellum yellowish brown, slightly darker upon the disk. Posterior half of the mesopleurae, a prominent spot upon the upper half of the sternopleurae, the upper and anterior part of pteropleurae, and a conspicuous spot above the anterior coxae pale yellow, otherwise metallic black. Squamae yellow, the halteres dark brown. *Abdomen:* Oval, widest at the end of the third segment, though barely wider, if at all, than the thorax. Sides of abdomen emarginate. The first segment dully shining black, only its anterior margin yellowish. Second segment narrowly blackish, along the base and again along the posterior margin, leaving the greater central part yellowish brown, which from above appears to extend fully to the lateral margin. Turned to the sides the lateral margin is narrowly blackish. Third segment except for the uniform dark posterior margin that occupies approximately a fifth of the length of the segment, wholly light brownish, dully shining. Fourth segment similar, with traces of a tiny pair of median subbasal lunate spots. Fifth segment dark brown with a conspicuous, median, basal, somewhat triangular opaque spot, its apex rounded. Hypopygium shining blackish. Pile along the margins of the abdomen and upon the disk of the segments, except on the extreme anterior margin of the second segment, blackish. *Legs:* Almost entirely light yellow, the apical third of the anterior tibia, all its tarsi, a narrow inconspicuous subapical ring upon the hind femora and the hind basi tarsi brown in color. Pile of the hind tibia except toward the ventral part of the apex and of the hind femora except narrowly toward the base and along the posterodorsal margin black. There are a few black hairs toward the apex of the middle femora *Wings:* Hyaline

Holotype: One male, Elcayo, British Honduras, February 21, 1909, F. Knab (U S.N.M. no. 55128)

Eumyiolepta circularis, n. sp.

Not very closely related to other known species though somewhat similar to *strigilata* Lw. of northern latitudes; characterized by the circular pattern of cream-colored scales upon the dull gray mesonotum.

Female. Length 7.5 mm; wing 7.5 mm. *Head:* Vertex narrow; together with the front and face and cheeks shining black. On each side of the front, growing more narrow ventrally, is a narrow band of punctate, brownish-yellow pubescence and a few brownish-yellow scales. There is a median impressed line down the front and a few scales on the upper part of the occiput along the eye Opposite the antennae and on the face there is some yellow to brownish-white pubescence narrowly connected with a large brown spot beneath the antennae. Lower, projecting, obconical part of the face and cheeks bare except for a narrow band of pubescence from eye margin to epistoma Antennae dark brown, the end of second segment and the middle base of third joint narrowly deep red Third joint one and one-half times as long as wide; broadly, bluntly rounded apically. Arista narrow, long, basally thickened and dark. Dorsum of the thorax dull black, feebly shining, with very appressed short bristles, a few scales cream-colored on the inside of the humeri and a narrow almost complete circle of cream-colored scales beginning at the inner end of the suture, tracing the posterior border of the suture and continuing along the side of the thorax over the posterior calli. These scales continue just before the scutellum, and, except for the interruption of the suture at their inner ends, the circle is complete. This large circle is connected with the scales of the humeri by a few scattered scales, and there are a few

others on the pleurae. Scutellum shining black, appressed bristly, without scales. *Abdomen:* Of the usual *Myiolepta* type, broad, rather strongly curled under from the end of the very flat second segment, dark shining black, with a bronze-purplish cast. The pile of the abdomen pure brassy in color, rather flat, very delicate and slender, but sharp and rather long for appressed pile. It is especially longer and thicker and golden on the last segment There are no scales on the abdomen. There is a bare, very narrow, perhaps accidental line on the middle of the third segment. *Legs:* For the most part shining black, the hind femora appressed golden-bristly, its base for one-fifth of the length reddish brown; at the extreme base paler. Bases of the other femora narrowly reddish, all the tips of the femora narrowly reddish, and the knees or tibiae basally light brown. Hind femora equipped on the outside with a row of nine sharp, long spines. There is also an inner row. Halteres pale orange, squamae light brown, brown fringed. *Wings:* With whole extent suffused with brown, a little bit lighter near the tip and posterior border and darker at the extremity of the costal cell and the two cells immediately beneath it. Stigmal cell brown.

Holotype: Female, Villa Nouges, Province Tucuman, Argentina, December 1928 (no. 16), in collection of the U. S. National Museum

Myiolepta greenei, n. sp.

In general somewhat similar to *strigilata* Lw. but different, in many respects; the mesonotal pile finer, less scalelike, more wiry; the abdominal pile flattened, longer, more abundant, less like scales. Base of wing with yellow, the middle with a brown cloud

Female. Length 9 mm. *Head:* Face, front, and vertex shining black. The face with a pair of triangles of grayish-white pubescence, narrowly connected with a central similarly colored area beneath the antennae and with a thin evanescent line or band of such pubescence from the lower eye margins to the epistoma. Front with very sparse, quite flattened, scalose, golden pile, a prominent median crease and on each eye margin a pair of semicircular pubescent spots. Post ocellar pile golden. Antennae black, the basal joints brown, the arista pale brown, black on its apical third *Thorax:* Mesonotum dull black with linear arrangement of short, flat, pale golden pile, much of it set in black microtubercles Scutellum flattened, rugose with black pile on the disk and short, scaly, golden pile on the rim. Pleurae black, obscurely shining, with sparse, flat, wiry pile. *Abdomen·* Black, obscurely shining, very dark brown along the sides of the segments and their extreme postmargins. The pile pale golden, somewhat erect on the second segment, becoming flattened on the third and extremely appressed, longer, wider, more scalelike and silky yellow or brassy upon the fourth segment. *Legs:* Shining blackish, with faint metallic cast, the pile white, thick, and close appressed. The anterior basitarsi and middle basitarsi yellowish white, the posterior basitarsi light brown. The ventral setae of the femora black. *Wings:* Strongly yellowish; about the base and on the basal half of the stigmal cell the yellow color arranged obliquely upon the wing. Middle of the wing, except the central portion of the marginal cells, dark brown and intensest along the region lying behind the stigma.

Holotype: A female, in the U. S. National Museum One paratype female in the U. S. National Museum (no. 55129) and two paratype females in the author's collection. All are from Villa Nouges, Province of Tucuman, Argentina.

Sarolepta, n. gen.

Small, dark-colored flies with short setaceous pile and stripes or patches of curly tomentum upon the thorax; face of female hollowed out beneath the antennae, the subapical cross vein joining the third longitudinal vein almost at the tip of the wing. Related to *Myiolepta*.

Head: Wide, the eyes large, high, broadly rounded, with the occipital margin well developed. The antennae are short; the first two joints short, the third joint oval, larger than the first two combined; arista long and slender. Face bare except for some pubescent areas, the epistoma a little protuberant, leaving the face concave beneath the antennae. *Thorax:* Mesonotum short pilose, with stripes or patches of curly tomentum. Scutellum triangular, the apex somewhat rounded. *Abdomen:* Oval, flattened, its pile short, appressed, setaceous. *Legs:* Hind femora slightly thickened, with inner and outer rows of short stiff spines upon the ventral surface. *Wings:* Small cross vein joining the third longitudinal vein quite near the apex of the wing.

Genotype: *Sarolepta dolorosa*, n. sp.

Sarolepta dolorosa, n. sp.

Not related to any species known at present. The mesonotum is slate-gray, the sides broadly orange; the abdomen is gray with its lateral margins cream colored; wings gray, the extreme tip whitish

Female. Length 8.5 mm; wings 7 mm. *Head:* Barely as wide as thorax when viewed from above. The head about the occiput is slightly concave, the occipital margins rather narrow above, growing rather wide below, silver-pubescent and silver-pilose. The vertex is somewhat swollen and convex; the ocelli are large but not conspicuous. The vertex very narrow, widening slowly down the front with a median, bare, black, shining ridge, which is produced as a narrow streak from the vertex part way down the front; it terminates in a point just before the end of the extensive yellow pubescence that occupies all the front except the lower third. Lower third of front flat, shining, very dark brown. Antennae with third joint very large, first two joints rather small, third joint very little longer than wide, evenly rounded, rather flat, the entire antennae pale orange. Arista long and slender. There is an area of yellow pubescence below the antennae that rises a short distance along the side by the eye, but is not continuous with the similarly colored area of pubescence upon the front The facial pubescence is continued downward along the facial strips barely reaching as far as the base of the tubercle in the middle and underlaid by a brownish background instead of black. Face and cheeks shining black. Tubercle of face low but broad, situated directly above the epistoma. Face produced but little, as much forward as down; eyes bare, head not very long, eyes therefore flattened. *Thorax:* Largely opaque, slate-gray with a bluish cast, this color occupying a very broad median area a little more than half of the width of the thorax. On each side of the dark area a portion is shining in color. This dark area is as wide as the scutellum, which is shining black, obscured by the flat, sharp, setaceous pile. On the sides of the thorax, from and including the humeri to the corners of the scutellum, is a wide band that is continuous with the entire pleurae; this band is bright, light orange and covered on the dorsum and upper mesopleurae with flat, thickened, possibly scaly, curly, golden pile. Scutellum large, rather produced and pointed, roughly equilateral, and triangular. Black, flat, setaceous pile on the dorsum of the thorax. Humeri pilose. *Abdomen:* A little wider than the thorax, not quite twice as long and wide, very

much flattened and, with one exception, entirely black with a dull shining bluish cast. Down the middle of each segment, except the last and first, runs a narrow gray vitta. There is a conspicuous, pale cream-colored border along the sides of the abdomen. Pile of abdomen flat, dark in color and pale on the side borders. Scutellum slightly directed upward without ventral fringe. Halteres cream colored. Squamae yellow. *Legs:* Shining black, the two middle basitarsi only being pale whitish. Hind femora a little bit thickened throughout, the greater thickening being at the point of outer two-thirds or one-third from the end. The hind femora has a row of numerous, prominent, stiff, black spines lying ventrally upon the inner and outer surfaces of the apical half; they are more numerous on the inside. Anterior and middle femora similarly spinose. Anterior femora quite bowed. *Wings:* Almost smoky brown or gray. The tip of the wing narrowly white or cream colored. The costal cell pale and the extreme base of the wing as far as the first cross vein bright orange.

Holotype: One female, Venezuela, "alte Sammlung." In the Vienna Museum, in Austria.

Edwardsietta, n. gen.

Broad, short-setate flies that resemble *Meromacrus* but have a pronounced tubercle upon the face and have the tomentum so characteristic of *Meromacrus* virtually or wholly absent. The marginal cell is widely open.

Head: Tall, anterior posterior length short. Eyes tall, twice as long vertically as horizontally, and bare. Antennae short, the third joint a little longer than wide, the apex roughly truncated dorsoapically. Arista long, slender and bare. Face concave beneath the antennae, the tubercle well developed. *Thorax·* Vittate, the pile rather short and setaceous, a little longer upon the pleurae. Scutellum small, the margin circular in shape *Abdomen·* Broad, short setate. *Legs.* Hind femora quite thickened, ventrally there are a series of slender spinous bristles. Hind tibia large, deep, and flattened, the apex truncate. *Wings:* Third longitudinal vein with a deep narrow loop into the first posterior cell. Marginal cell widely open.

Genotype: *Edwardsietta ochracea,* n. sp. Named in honor of F. W. Edwards, late of the British Museum, a splendid gentleman and an enthusiastic and tireless worker in his chosen field.

Edwardsietta ochracea, n. sp.

Not related closely to any species known at the present time. In general appearance suggestive of *Meromacrus* but with the marginal cell well open. Broad, dark-brown flies with pale yellowish-brown pollen; hind femora light brown with a blackish middle annulus.

Female Length 13 mm; wing 10 mm. *Head:* Rather flat, wider than the thorax, beautifully rounded from the front, eyes prominent, vertex a little swollen, dark brown; ocelli close set, red. The occiput is somewhat tumid, with rather squared margins, very densely pubescent; front golden-pubescent on the upper half, narrowly along the eyes, and upon a narrow median impression. Lower part of front just before antennae bare and shining brown, but pale yellow directly in the middle. Pile of vertex and front and behind the ocelli rather short but thick and bushy, and pale golden. Face with a very wide silver-pubescent band connected on the prominent concavity across the face and below the antennae. Tubercle and the face below are bare, the former rather prominent, owing to the deep concavity below the antennae. A very wide band on the anterior part of the cheeks black and

shining bare. Antennae short, the third joint large, flattened, about as long as wide, a little narrow apically, light brown, the thickened arista is elongate, its apex yellow. *Thorax:* Dorsum very gently convex, in ground color dark brownish black but almost completely obscured by the very dense light orange-brown pollen. There are two darker vittae on the anterior part of the thorax, which merge into a general dark-brown area on the posterior half, which, however, does not reach the scutellum. There is a large, obscure, dark spot on the lateral sides of the dorsum before the suture, widely separated from the two median vittae and the posterior part of which spot is lighter. This spot, the two median vittae, and the postcalli, when viewed from the front, may be seen to have pile of a different character. Scutellum entirely light orange-brown; nowhere is there tomentum present unless the pile just before the base of the wing be called tomentum. *Abdomen:* Broad, wider than thorax, dark, shining, chestnut-brown, very dense, very short, appressed, black-setate; a median, narrow, orange-setate vitta on the second segment that does not reach the apex of the segment. The setae in the corners of the third and fourth segments are pale. First segment light orange-brown, the sides of the segment posteriorly and the anterior corners of the second segment blackish. *Legs·* Largely blackish or very dark brown, the basal half of the hind femora, anterior basal third of first and second femora, the basal two-fifths of hind tibiae, and a lateral, broad, elongate, spot on the hind femora all pale brownish yellow. Many black, slender bristles or spines ventrally, just back of the apex of the hind femora. Hind femora very much thickened, especially on the dorsal side and apex more narrowly slender. *Wings.* Somewhat smoky on the apical part and especially near the dip of the vein Stigmal cell pale brown, stigmal cross vein present, base of wings pale orange up to costal cross vein. Vena spuria lightly chitinized. Marginal cell open.

Holotype: One female, Barro Colorado, April 17, 1926. C. T Greene, collector (U.S.N M no 52903).

Microdon chapini, n. sp.

Somewhat related to *auroscutatus* Curran. Deeply punctate, dark-brown flies with beautiful golden pile, mesonotal suture and prescutellar area with longer, golden pile.

Male. Length 9.5 mm without antennae; wing 6.5 mm; first joint of antennae 1 mm. *Head.* With the occiput on the upper third exceedingly tumid and somewhat swollen, the eyes somewhat approximated but by no means close; front, vertex, cheeks, and face, except for a small, vertical, elongate, light-brownish spot on the sides touching the eyes, everywhere shining black. Pile of face, cheeks, and front silvery yellow; upon the front the pile is divided in the middle of the impressed line at the approximation of the eyes; above that line it is directed upward, below it is directed downward. First antennal joint dark brown, twice as wide at the apex; about as long as the distance from back of occiput to the transverse impression of the front; not quite so long as fore tibiae. Second joint rather short, conical. Third joint lacking. Face evenly convex in profile and also when viewed from above. *Thorax:* Dull shining black, exceedingly rugose or papillose The hairs semiappressed, setaceous, and fairly long. Along the suture, directed backward, is a beautiful tuft of thick, coarse, bright golden hairs that continues to grow wider on the mesopleurae, becoming silvery below. There is a similar patch or band on the posterior part of scutellum directed straight outward, very conspicuous, covering two short spines that are set rather wide apart. There is also a similar

narrow band on the thorax, just before the scutellum, parted in the middle, each side directed outward so that only one side is visible at a time. *Abdomen:* Elongate, a little over twice as long as its greatest width, which is on the flat, flared base of the fused first and second segment. First segment deeply produced into the center of the second segment, its apex somewhat truncate and the base of the second segment pitted in little scooped-out pits and the margin of the second segment fluted. Second, third, and fourth segments deeply and closely pitted, but the pits are not so large as those along the first segment. End of first segment marked by a narrow band of bright golden pile flattened and narrowly interrupted in the middle; third segment similarly equipped, more widely interrupted, the pile directed outward and downward. Fourth segment with a similar band, a little wider, of even longer pile, which instead of being interrupted in the middle is continuous and produced forward in a rounded, anteriorward production for a short way. Remainder of abdominal pile largely silvery intermixed with black. The inconspicuous hypopygium is long, black pilose. *Legs:* Shining black, apex of the middle femur, apical third upon the outside of the front femur, front and middle tibiae, except for a middle black annulus, all very dark shining red. All the tarsi lighter red. Halteres dark orange-brown, squamae whitish with white fringe. *Wings:* Villose, with very dark brown veins; stigmal cell brown, vena spuria heavily chitinized. Stigmal cross vein strongly chitinized and wings rather sharply marked with characteristic pattern The smoky-gray pattern consists of a spot filling out the basal part between the origin of second and third veins, which is connected by way of the stigma with a more extensive area upon the outer third of the wing. This area occupies all the outer part of marginal and submarginal cell, all the outer part of first posterior cell from just before the spur vein, except a somewhat rectangular clear spot in the outer half of the cell, also the extreme upper end of second posterior cell, the outer border of the final sections of third, fourth, and fifth longitudinal veins

Holotype: One male, Patmeung Mountains, Siam, January 18, 1928, T. D. A. Cockerell, collector (U.S N.M. no. 52911).

Microdon gloriosa, n sp.

Belongs in the *aurosculatus* Curran group. Abdomen coarctate, thickly appressed golden pilose; second segment with a pair of clear, hyaline fenestra of characteristic shape.

Male. Length 10 mm; wing 8.5 mm, antennae 1.9 mm. *Head:* Large, very little wider than thorax. Occiput tumid throughout, conspicuously tumid on the upper half. The vertex a little swollen, the eyes approximated, separated by a distance little more than the length of the distance between the ocelli. Occiput throughout, to the upper corner of the eye, clothed with long, flattened, crinkly, backward-directed, coarse, brilliant golden pile. At the impression on the front, between the approximation of the eyes the golden pile above is directed backward and below it is directed forward. Front and face shining steel-blue with a pale-yellow stripe or spot on the greater part of the margin of the face bordering the eye, narrow above and wide below, separated in the middle below by a wide band of black; otherwise the head is everywhere shining steel blue-black. Antennae elongate, first joint a little longer than the last two, second joint a little more than half as long as the third joint. Arista short, basally thickened, orange at base, brown outwardly. Eyes bare, shining with a waxy appearance Pile of face and head everywhere brilliant golden. Last two antennal joints dark brown, lower half of first orange, upper half black. Lower part of epistoma set off from face by a deep crease; face

gently rounded. *Thorax:* Mesonotum and scutellum dark shining blue-black, covered with tufts of brilliant golden pile and scattered hairs of the same color. A tuft of such pile is located behind the humeri, a band of it in front of the suture running narrowly along the sides of the thorax, especially on the postcalli. The whole of the scutellum is so covered; the pile is more prominent in the middle and as a thick diagonal mat along the mesopleurae. Halteres pale yellow; squamae pale yellow, yellow fringed. There are two small, pale, rather widely separated points on the scutellum. *Abdomen:* Elongate, the fused first and second segment much flattened, not quite so broad as the thorax, becoming as broad as the thorax only at the anterior ends of the second segment. First segment deeply set into the second segment, its base deep punctate, the margin broadly, evenly rounded and fluted, the whole segment shining black with just a little golden pile in the lateral corners. The middle of the second segment is a raised, rounded, widening ridge, so that the anterior portion of the lateral part of this segment is a flat triangle whose inner half is pale-translucent and hyaline. The remainder of the anterior part is brown. The rugose middle ridge is very dark brown, nearly black, the posterior corners, but not the posterior middle, with matted golden pile, posteriorly directed and the sides of the anterior part of the segment with golden, matted, straight, inwardly produced pile. The abdomen is narrowest at the end of the second segment, and it is only as wide there as four-fifths the length of the second segment in the middle. Last two segments developed into a thick, heavy, much pitted brown, almost black, very convex club, which is widest just before the end of the fourth segment. The entire sides of the third segment, except narrowly at the base and rather broadly in the middle, covered with straight backwardly directed matted golden pile. Fourth segment with similar but much more restricted lateral golden pile, which does not reach the end of the segment on the sides; however, before the end of the segment near the top and widely separated, there is a large, oblique patch of matted golden pile directed both posteriorward and inward; the extreme apex of this segment is pale brownish yellow, not visible from above. There is a diagonal depression just posterior to the dorsal area of the golden pile. Hypopygium pale brown, pale pilose, not conspicuous. Pile elsewhere on the abdomen, the dorsal parts of the segment, black. *Legs:* Hind femora black, narrowly brown basally and ventrally, hind tibiae very dark brown, remainder of legs light reddish brown, the tarsi still paler. Hind basitarsi not especially thickened. *Wings:* Stigmal cell pale brownish, a very conspicuous stigmal cross vein present, a well-developed spurious vein and the whole wing, especially the apical third, somewhat smoky. Veins very dark brown. There is a long spur vein into the first posterior cell, and the lower corners of the first and second posterior cells are broadly rounded and without spur.

Holotype: One male, Patmcung Mountains, Siam, January 1928, T. D. A. Cockerell collector (U.S.N.M. no. 52910).

MATHEMATICS.—*Intuitive and descriptive geometry of function space: Metric properties and transformation of coordinates.*[1] Bruce Longtin, Department of Chemistry, Illinois Institute of Technology, and Merle Randall, Department of Chemistry, University of California. (Communicated by Frederick D. Rossini.)

In a previous paper[2] a graphical method of representing spaces of an indefinitely large number of dimensions was developed. The method consists essentially in dividing an interval Δ into n equal subintervals and erecting an ordinate equal to one of the vector components (i.e., Cartesian coordinate numbers) at the center of each subinterval. A number of geometrical figures were studied descriptively by the use of this representation.

In everyday 3-space, geometric intuitions are developed through the ability to survey an object from many viewpoints; to pick it up, turn it around, and move it back and forth. These operations of rotation and translation enable one who can see only two dimensions at a time to appreciate the geometry of a third dimension. The significant result of such geometrical observations is the conclusion that certain geometric features of an object, such as lengths and angles, remain unaltered by rotation and translation. It is this property that gives meaning to the operation of geometrical measurement.

The analytic aspects of the metric properties of function space form one of the most thoroughly investigated fields of functional theory. For this reason the analytical results will be presented as briefly as possible except where clarification is necessary.

SCALAR PRODUCT OF TWO VECTORS

The scalar product $\mathbf{u} \cdot \mathbf{v}$ of the vectors $\mathbf{u}$ and $\mathbf{v}$ is defined geometrically as the product of their lengths $|u|$ and $|v|$ times the cosine of the angle θ between the two vectors;

$$\mathbf{u} \cdot \mathbf{v} = |u||v| \cos \theta. \tag{1}$$

If the two vectors u and v are identical, the angle between them is zero and cos θ is unity. In this case, the scalar product u u is the square of the length of the single vector;

$$\mathbf{u} \cdot \mathbf{u} = |u|^2. \tag{2}$$

Since the scalar product may be evaluated by methods that are independent of any previous knowledge of the length of the vectors, equation 2 permits an analytic evaluation of the length of any vector. Equation 1 may then be solved for the angle θ between two vectors, in the form

$$\cos \theta = \mathbf{u} \ \mathbf{v}/|u||v|, \tag{3}$$

or

$$\theta = \cos^{-1}[\mathbf{u} \ \mathbf{v}/|u||v|]. \tag{4}$$

Thus the metric properties of any Euclidean space may be expressed in terms of the scalar products of vectors. Such an expression is much simplified by introducing the general vector notations.

Base vector systems.—An orthogonal set of vectors consists of vectors mutually perpendicular. The scalar product of any two vectors of such a set is zero (cos $90° = 0$), as indicated by equation 1, unless the two are identical. A normalized set of vectors consists of vectors each of which is of unit length. An *orthonormal* set is both orthogonal and normalized. If the vectors $\mathbf{e}_i^0$, $\mathbf{e}_j^0$, $\cdot$, form an orthonormal set, they satisfy the equation

$$\mathbf{e}_i^0 \ \mathbf{e}_j^0 = \delta_{ij}, \tag{5}$$

where δ_{ij}, (Kronecker's delta symbol) is zero except in the case that i and j are identical; then it takes the value unity.

In Euclidean spaces of a finite number of dimensions, any vector v is readily expressed in terms of an orthonormal set $\mathbf{e}_i^0$, $\mathbf{e}_j^0$, $\cdots$, in the form

$$\mathbf{v} = v_1\mathbf{e}_1^0 + v_2\mathbf{e}_2^0 + \quad + v_n\mathbf{e}_n^0 = \sum_1^n v_i\mathbf{e}_i^0, \tag{6}$$

the coefficients v_i, v_n, $\cdots$ being scalar quantities. The set of vectors $\mathbf{e}_i^0$, $\mathbf{e}_j^0$, $\cdots$ is then called a *base vector system*. Any system of vectors may be used as a base vector system provided the number of base vectors is the same as the number of dimensions of the space under consideration, while no one of the base vectors may be expressed in terms of the others by any equation such as equation 6.

If the vectors u and v have been represented in terms of the same

orthonormal base vector system, e_i^0, e_j^0, $\cdots$, their scalar product takes the form

$$u \cdot v = \left(\sum_1^n u_i e_i^0 \right) \left(\sum_1^n v_j e_j^0 \right) = \sum_{i=1}^n \sum_{j=1}^n u_i v_j e_i^0 \cdot e_j^0. \qquad (7)$$

Recalling equation 5, we see that this result may be reduced to the simple form

$$u \cdot v = u_1 v_1 + u_2 v_2 + \quad + u_n v_n = \sum_{i=1}^n u_i v_i. \qquad (8)$$

Two special cases are of interest. If the vector u is one of the base vectors, e_i^0, then the coefficients u_1, u_2, $\cdots$, u_n are all zero except u_i, which is unity. In this case, the scalar product

$$e_i^0 \cdot v = v_i \qquad (9)$$

is the length of the vector v times unity times the cosine of the angle between v and the base vector e_i^0. Thus the coefficient v_i is the length of the projection of the vector v on the axis of the vector e_i; it is the vector component in this direction. If the vectors u and v are identical, one obtains the formula

$$u \cdot u = u_1^2 + u_2^2 + \quad + u_n^2, \qquad (10)$$

which is the ordinary Euclidean expression for the square of the length of the vector v.

From equation 10 it is evident that the length of the vector u will approach an infinite value as the number of dimensions is increased indefinitely, if each component has a finite value. If all components of the vector have the same order of magnitude, the length of the vector will approach a finite limit only if the individual components are of infinitesimal length.

Such vectors, whose components are of infinitesimal length, are of great importance in the geometry of function space. They are best represented in terms of a *reduced base vector system* defined by the equation

$$e_i' = (\Delta/n)^{1/2} e_i^0. \qquad (11)$$

The vectors of the reduced system are orthogonal but are not normalized. They have the same directions as vectors of the orthonormal set, but each has a length $(\Delta/n)^{1/2}$ rather than unity. This length approaches an infinitesimal value as the number, n, of dimensions increases.

The quantity (Δ/n) is the width of each of the n subintervals into which the interval Δ is subdivided in order to construct the block

diagram representation of an n-space vector. When the number of subdivisions becomes infinite, (Δ/n) may be replaced by its equivalent, dx. Here x denotes the distance[3] $(a+(i/n)\Delta)$, whose increment is (Δ/n) when the index i increases by unity. In this case equation 11 takes the form

$$\mathbf{e}_i' = (dx)^{1/2}\mathbf{e}_i{}^0. \tag{12}$$

In order to represent the vector $\mathbf{v}$ in terms of the reduced base vector system, new components, v_i', must be defined which are $(1/dx)^{1/2}$ times as big as the original components:

$$v_i' = v_i/(dx)^{1/2} \tag{13}$$

and hence may be finite rather than infinitesimal.[4] Equation 6 then takes the form

$$\mathbf{v} = v_1'\mathbf{e}_1' + v_2'\mathbf{e}_2' + \quad + v_n'\mathbf{e}_n' = \sum_1^n v_i'\mathbf{e}_i'. \tag{14}$$

Scalar product in Hilbert space.—A Euclidean space of an infinite number of dimensions is known as a Hilbert space.[5] By using the reduced base vector system for such a space, equation 8 becomes the sum of an infinite number of terms $u_i'v_i'(\Delta/n)$, whose limit is the integral

$$\mathbf{u}\ \mathbf{v} = \int_a^{a+\Delta} u'(x)v'(x)dx. \tag{15}$$

In this equation, the subscript i has been replaced by the variable x, which is $[a+(i/n)\Delta]$. The square of the length of any vector in Hilbert space is thus given as

$$|u|^2 = \mathbf{u}\ \mathbf{v} = \int_a^{a+\Delta} [u'(x)]^2dx. \tag{16}$$

Angle between two vectors.—The scalar product $\mathbf{u}\ \mathbf{v}$ and the two lengths $|u|$ and $|v|$ appearing in equation 4 may be evaluated with the help of equations 15 and 16. Proceeding in this way, Frank and Pick[6] have made a rather detailed study of the spherical geometry of function space. Their valuable work on the angles which

[3] RANDALL and LONGTIN.   *Op cit*

[4] Cf KOWALEWSKI, G   *Ueber Funktionenräume*, Sitz Akad Wien 120(2a 1)· 77 1911.   Kowalewski obtains this result without mentioning the role of the base vector system

[5] HILBERT, DAVID   *Grundzüge einer allgemeinen Theorie der linearen Integralgleichungen*, Leipzig and Berlin, 1912, a collection from Gött Nachr   1904: 49, 213; 1905: 307; 1906: 157, 439; 1910: 355

[6] FRANK and PICK   Math. Ann 76:354   1915.   PICK · Compt Rend. 158: 549 1914.   These two papers contain the only cases found in which the geometrical representation of vectors in function space has actually been used.

may exist between "convex" functions need not be repeated here.

As one interesting application, consider the angle between a vector **v** whose length $|v|$ is unity, and one of the orthonormal base vectors, $e_i{}^0$. In the formulas, the vector **u** may be replaced by $e_i{}^0$. Both of the lengths $|u|$ and $|v|$ of equation 9 are unity. In accordance with equation 9, the scalar product $e_i{}^0 \cdot v$ must have the value v_i, equal to $v_i'(dx)^{1/2}$, and this result is obtained from equation 16 when the integration is carried out properly. Consequently,

$$\theta = \cos^{-1}\left[v_i'(dx)^{1/2}\right] \sim \left[\pi/2 - v_i'(dx)^{1/2}\right]; \qquad (17)$$

the angle θ deviates only slightly from 90°, or $\pi/2$ radians, provided the component v_i' is finite.

In the previous paper,[7] we chose to represent a vector in function space by means of a continuous (or piecewise continuous) curve with no infinite ordinates. The function $v'(x)$ representing the vector **v** is in this case continuous and finite. Consequently every reduced component v_i' of the vector **v** is finite, and the angle θ that it makes with every vector of the base vector system is nearly 90°.

In 2-dimensional space there is no region that is nearly 90° away from both axes. The closest approach to such a region is one lying at about 45° away from both axes. In 3-space a region may be found that lies about 55° away from all three axes. As the number of dimensions increases, the angle between a base vector and the vector that makes equal angles with all base vectors increases toward 90°. With an infinite number of dimensions there is a great abundance of space in the region *nearly* 90° away from all the coordinate axes (base vectors). Such an abundance of space will be noticed repeatedly in regions of function space which in analogy to common 3-dimensional experience would at first seem insignificant.

The integrating vector.—A vector all of whose components are zero or unity in terms of the reduced base vector system has peculiarly important properties. Let the subscript E denote the ensemble (or collection) of indices for which the components of such a vector have the values unity rather than zero. The vector having these components is designated as e_E. In particular, when the components are zero for all indices except those between b and c and unity for all indices in this interval (inclusive of b and c), the vector will be designated as $e_b{}^c$. Such a vector is represented in Fig. 1 by the method previously developed, in which the vector components are plotted as ordinate against the indices (scale $1/n = $ unity) as abscissa.

[7] RANDALL and LONGTIN. *Op cit*

The scalar product $e_b{}^c$ v proves to be simply the integral

$$e_b{}^c \ v = \int_b^c v'(x)dx, \tag{18}$$

extended over the interval from b to c. This is evident when one substitutes for $u'(x)$ in equation 15 the components of $e_b{}^c$, which are zero except in the interval (bc) and unity within this interval. In a more general sense,[8] the scalar product e_E v is the integral of $v(x)$ over the ensemble of values of x included in E. Because of the role which the vector e_E may be considered to play in the theories of integration, we may designate it as the *integrating vector*.
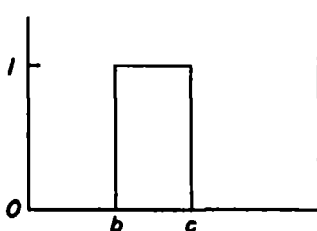
Fig 1 —A vector all of whose components between indices b and c are unity. (Scale, $1/n =$ unity)

In the previous paper[9] the phase diagrams of complex chemical mixtures were given as an example of the application of the methods therein developed. When the mixture is that of a series of hydrocarbons and other volatile substances, the index i is taken as the "true boiling point," Θ, of the component substance. The original data from which the analysis of the mixture is obtained give the total weight of material whose true boiling point is less than Θ. The desired analysis gives the weight of substance boiling between Θ and $\Theta + d\Theta$. If $W(\Theta)$ represents the total weight boiling below Θ, and $w(\Theta)d\Theta$ the desired value[10]

$$W(\Theta) = e'_0{}^\Theta \ w = \int_0^\Theta w(\Theta)d\Theta. \tag{19}$$

The weights of the individual components, which are used as the vector components in the phase diagram, are therefore obtained as

$$w(\Theta) = dW/d\Theta. \tag{20}$$

This serves to indicate another manner in which the representation

[8] Compare Lebesgue integration; LEBESGUE, *Leçons sur l'intégration*, Paris, Gauthier-Villars, 1928.

[9] RANDALL and LONGTIN. *Op. cit.*

[10] Here and subsequently it will be assumed that the reduced base vector system is to be used, and the designation by accents omitted except where confusion may arise

in function space may arise. Usually in this case the condition $e'_0{}^\infty \; w = 1$ is also imposed so that $w(\Theta)$ represents the weight fraction rather than total weight of the component.

Orthonormal vector sets.—Consider an orthonormal set of vectors $e_\alpha{}^0$, $e_\beta{}^0$, $\cdots$, $e_\nu{}^0$, different from the base vector system $e_1{}^0$, $e_2{}^0$, $\cdots$, $e_n{}^0$. Each vector $e_\lambda{}^0$ of this set can be represented in terms of the reduced base vector system as the sum of its components $e_{\lambda i}'e_i'$. The coefficient $e_{\lambda i}'$ is the magnitude of the reduced component of $e_\lambda{}^0$ in the direction of the base vector $e_i{}^0$. In the limit of an infinite number of dimensions, this coefficient becomes a function $e_\lambda'(x)$, which may be used to represent the vector graphically by the method previously discussed.

If the vectors $e_\alpha{}^0$, $e_\beta{}^0$, $\cdots$, $e_\nu{}^0$ form an orthonormal set, they must satisfy a relationship like equation 5. Expressed in the form appropriate to function space, this requires that

$$e_\kappa{}^0 \; e_\lambda{}^0 = \int_a^{a+\Delta} e_\kappa'(x)e_\lambda'(x)dx = \delta_{\kappa\lambda} \qquad (21)$$

for all pairs of subscripts κ, λ. A set of functions $e_\alpha'(x)$, $e_\beta'(x)$, $\cdots$, $e_\nu'(x)$ that satisfy equation 21 are said to be orthogonal and normalized with respect to the interval Δ; this is not necessarily true with respect to any other interval of the variable x. An example is the set of functions $(1/\Delta)^{1/2}$, $(2/\Delta)^{1/2} \sin (\theta)$, $(2/\Delta)^{1/2} \cos (\theta)$, $(2/\Delta)^{1/2} \sin (2\theta)$, $(2/\Delta)^{1/2} \cos 2\theta$, $(2/\Delta)^{1/2} \sin 3\theta$, $\cdots$, where θ has the value $2\pi x/\Delta$. The functions of this set are all orthogonal[11] and normalized with respect to any interval of width Δ but of no other width.

Transformation of axes.—Since the set of vectors $e_\alpha{}^0$, $e_\beta{}^0$, $\cdots$, $e_\nu{}^0$ are orthonormal, they may serve equally as well for a base vector system as the original set $e_1{}^0$, $e_2{}^0$, $\cdots$, $e_n{}^0$. The components of a vector v were represented in the original system by the function $v'(x)$. In the new system the values of the components are found with the help of equations 9, 12, and 13 as

$$v_\lambda' = v \; e_\lambda' = \int_a^{a+\Delta} v'(x)e_\lambda'(x)dx. \qquad (22)$$

As an example, the vectors $e_\lambda{}^0$ may be those whose representative functions, $e_\lambda'(x)$, are terms of the sine and cosine series discussed above. In this case the component v_λ' will be recognized as the coefficient of $e_\lambda'(x)$ in the Fourier series expansion for $v'(x)$.

If the system $e_\alpha{}^0$, $e_\beta{}^0$, $\cdots$, $e_\nu{}^0$ is to serve as a complete base vector

[11] See COURANT. *Differential and integral calculus* 1: chapter 9   1939

system in function space the number, n, of vectors in the set must be infinite. To represent a vector $\mathbf{v}$ graphically in terms of the new system, an interval Δ' (not necessarily the same as Δ) is divided into n subintervals. At the center of the λth interval an ordinate of height v_λ' is erected (for all values of λ). In the limit, the subscript λ may be replaced by a continuous variable ξ, whose value is $[a' + (\lambda/n)\Delta']$. The vector $\mathbf{v}$ is then represented in the new system by a function $v'(\xi)$, not the same as the function $v'(x)$.

For example, consider the vector $\mathbf{v}$ which is represented in terms of the system $\mathbf{e_1}^0, \mathbf{e_2}^0, \cdot \quad , \mathbf{e_n}^0$ by the curve and three isolated points of Fig. 2.
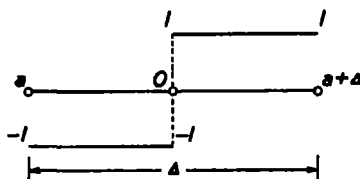
Fig 2 —The vector $\mathbf{v}$ represented in the system $\mathbf{e_1}^0, \mathbf{e_2}^0, \cdots, \mathbf{e_n}^0$

A new base vector system $\mathbf{e_\alpha}^0, \mathbf{e_\beta}^0, \quad \cdot , \mathbf{e_\nu}^0$ is represented in terms of the old by means of the Fourier series terms listed above. The
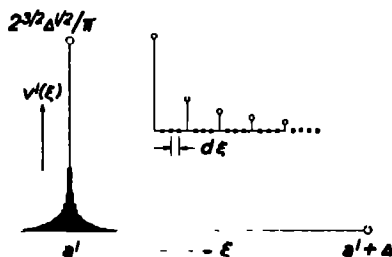
Fig 3 —The same vector $\mathbf{v}$ (Fig 2) represented in terms of a new coordinate system $\mathbf{e_\alpha}^0, \mathbf{e_\beta}^0, \quad , \mathbf{e_\nu}$ In the inset the ξ-axis has been infinitely magnified to show the details close to the point $\xi = a'$ The actual width of the shaded block at a' is infinitesimal

Fourier coefficients of the function $v'(x)$ of Fig. 2 are all zero except those of the odd-numbered sine terms. If the normalized functions are used, the coefficients of these sine terms are $(2^{3/2}\Delta^{1/2}/\pi\kappa)$ where κ is the (odd) number of the sine term, counting sine terms only. These are the vector components, v_λ. Let j denote the number of the term in the order listed previously, and define the variable ξ as $[a' + (j/n)\Delta']$ where n is the total number of all terms. Then the vector components v_λ are represented by a function $v(\xi)$, which has alternately the values

zero and $(2^{1/2}\Delta^{1/2}/\pi)[d\xi/(\xi-a')]$. Between each pair of points for which its value is definite are three points for which the value is zero.

The function $v(\xi)$ obtained in this manner is shown in Fig. 3. It has finite values only as long as $(\xi-a')/d\xi$ remains a denumerable quantity. After $(\xi-a')d\xi$ reaches an infinite value (not denumerable) the remaining values of $v(\xi)$ differ only infinitesimally from zero. With an infinite (not denumerable) number of dimensions, this point is reached before ξ differs from a' by more than an infinitesimal amount, as indicated in the figure.

In this example, the new coordinate system contains several axes [those represented by $(2/\Delta)^{1/2}\sin\theta$, $(2/\Delta)^{1/2}\sin 3\theta$, and $(2/\Delta)^{1/2}\sin 5\theta$ in particular] that lie in nearly the same region of function space as does the vector $\mathbf{v}$. This is evidenced in part by the similarity in form between the function representing any one of these base vectors and that representing $\mathbf{v}$ [which is *crudely* sinusoidal]. Consequently the vector $\mathbf{v}$, as represented in the new coordinate system, has important components only in these few directions; the function $v'(\xi)$ has non-zero values for a few values of ξ.

The transformation from one orthonormal base vector set to a second in Hilbert space leaves the scalar product of any two vectors unaltered. Consequently, the length of a vector and the angle between two vectors are quantities that may be calculated in the same way and with the same answer, regardless of the base vector system used in describing the vectors. Thus, for example, the length of the vector $\mathbf{v}$ obtained by applying equation 16 will be the same whether the function $v'(x)$ and variable x or the function $v'(\xi)$ and variable ξ are used. The area under the curve obtained by squaring the ordinate of Fig. 2 is the same as that under the block diagram obtained by squaring the ordinates of Fig. 3.

AUXILIARY PROJECTIONS

In the previous paper[12] it was shown that a desired principle projection of function space into two or three dimensions is obtained by constructing a 2- or 3-dimensional figure with Cartesian coordinates equal to values from the complete vector diagram corresponding to the desired two or three particular indices of the set x.

In the practice of descriptive geometry the use of auxiliary projections is quite helpful. The auxiliary projection may be considered as a principle projection relative to a coordinate system whose orientation is different from the original coordinate system. In function

[12] RANDALL and LONGTIN. *Op cit.*

space, the auxiliary projection may be obtained by representing the geometrical figure in terms of a new coordinate system $e_\alpha{}^0$, $e_\beta{}^0$, $\cdots$, $e_\nu{}^0$, taking it as a principal projection relative to the new representation. Thus the transformation of axes by the methods discussed above affords a new point of view from which to survey the function space figure by means of projections.

For example, one may study the configuration of two intersecting straight lines $(r+su)$ and $(r+tv)$ by looking at it from all possible angles. In other words, its principal 2-dimensional projection will be taken with respect to every different possible base vector system. These projections will all show two intersecting straight lines, with varying degrees of foreshortening of lengths and angles. They are like the various aspects obtained by looking at a pair of intersecting lines from different directions in ordinary 3-space.

Of all the different aspects of a plane figure, the most important is that which looks directly at the plane, so that the figure shows no foreshortening. To obtain this projection one makes use of axes consisting of two mutually perpendicular lines lying in the plane and other axes perpendicular to the plane and each other. These other axes are unimportant, since they are to be suppressed in taking the projection.

In applying the method to the two intersecting lines, it is convenient to choose as the axes lying in the plane one of the two lines, and a second perpendicular to it. It may be shown that the component of a vector v parallel to the vector u is given by the expression [u(v u)/(u u)]. Consequently the expression [v − u(v u)/(u u)] gives the component of v perpendicular to u. It must necessarily lie in the plane of u and v, and is suitable for use as the second of the two axes. The ratio (v u)/(u u) may be determined from equations 16 and 17 with the help of graphical integration, if the representative functions $u(x)$ and $v(x)$ are known. The function $u(x)$ is multiplied by this ratio and subtracted from $v(x)$ to construct a function representative of this second coordinate axis.

Fig. 4 (left) represents a radius vector r that extends to the intersection of vectors u and v. In Fig. 4 (right vector u has been taken to give the direction of one coordinate axis while a second is taken along the component of v that is perpendicular to u. The components of v and r along the directions of these two axes were obtained by the method that gives [u(v u)/(u u)] as the component of v parallel to u. The projection of this figure taken normal to the plane of u and v was constructed from these vector components. In this figure, the lines [r+su] and [r+tv] actually appear as intersecting lines. Furthermore
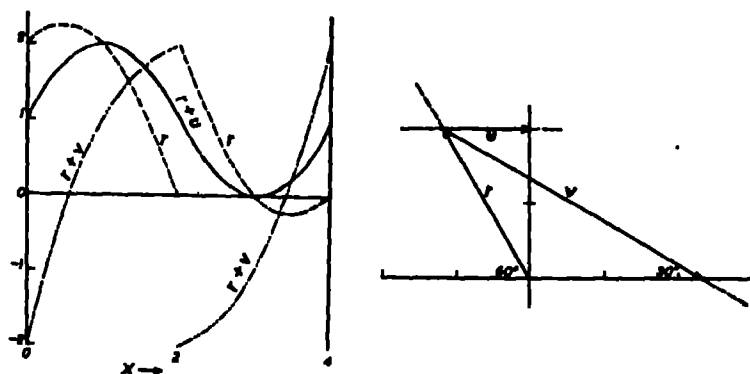
Fig. 4 —Normal projection of the intersection of two straight lines.

the angle of 30° between them is that calculated from the function $u(x)$ and $v(x)$ by equations 4, 15, and 16

Frank and Pick[13] have by similar means obtained a projection of the intersection of a plane and hypersphere, using the given plane as the plane of projection. The projection of course appears as a circle. Many similar exercises in projective geometry may be carried out by the same means.

NONORTHOGONAL AND NONEUCLIDEAN SYSTEMS

In ordinary descriptive geometry occasional use is made of oblique projections; in these the projection rays are not normal to the projection plane. Such projections are to be obtained by representing the figure in terms of a nonorthogonal base vector system of which one group defines the projection space, and the remaining group defines a space parallel to the projection elements. The desired projection is then obtained by suppressing the coordinates parallel to the projection elements, just as a principal orthogonal projection is obtained.

The transformation is most readily accomplished with the aid of the set of vectors reciprocal to the base vector set (i.e., if the base vector system is covariant, the other system is the corresponding contravariant system of vectors). The representative functions of these two base vector systems form what is known as a biorthogonal system. This transformation is not of sufficient importance to be described in detail.[14]

[13] FRANK and PICK. *Op. cit*

[14] The equations of the transformation may be obtained as a generalisation of the equations given in WILLS, *Vector tensor analysis*, §20, 1931, or any other text on the subject The analytic generalisation to function space is the subject of the following works: SCHMIDT, ERHARD, *Dissertation*, Gottingen, 1905; LEVY, P , *Leçons d'analyse fonctionnelle*, Gauthier-Villars, Paris, 1922; COURANT and HILBERT, *Methoden math Physik I* , pp 19, 34 Berlin, J Springer, 1924.

Various definitions of non-Euclidean metric of function space have been given at different times. Chief of these are those given by Hölder[14] and by Fréchet.[16] Hölder's definition is a generalization of the Euclidean definition, while Fréchet's is generically unrelated to the Euclidean definition. In any case a rotation will be considered as a transformation of axes, without shift of origin, which preserves all the (non-Euclidean) distances in the function space save certain singular ones.

Proceeding in like manner, all the propositions of this paper may be reproduced in analogue for each non-Euclidean metric. Such a task is too lengthy for the present paper. There is an alternative procedure of studying non-Euclidean geometry that will be discussed further in a subsequent paper. It arises as a generalization of the transformation theory in tensor analysis. It has already been briefly discussed by Delsarte[17] in a series of papers on subgroups of the Fredholm transformation.

<div align="center">CONCLUSIONS</div>

In function space purely mechanical methods of measurement and of shifting the orientation of figures are not possible. Analytical methods must be substituted. These methods have been collected. and some attempt has been made to give them physical significance. Equation 16 serves as the basis for measuring distances in function space, while equations 4, 15, and 16 serve to measure angles when the geometrical figures have been represented by the proposed method.

By representing the geometrical figure in terms of new coordinate systems, different oblique views are made available. The same transformation may serve a different purpose. The observer may imagine that he has changed his viewpoint to coincide with one axis (or more) of the new system. He might then grasp the coordinate axes, rotating them into coincidence with the old axes. If the geometrical figure moves with the axes, it will continue to be represented in terms of these moving axes by the same diagrams, although its representation in terms of the fixed axis system is changing. Hence the use of different axis systems allows one the freedom of either a movable observer or a movable object.

The chief methods of descriptive geometry are the construction of principal and auxiliary projections (including the normal projection), the construction of straight lines, and the location of intersections.

[14] HÖLDER   Die mathematische methode, Springer, Berlin, 1928.
[16] FRÉCHET.   Les espaces abstraits, Gauthier-Villars, Paris, 1924.
[17] DELSARTE   Compt Rend 186: 415, 1095, 1412, 1513.   1928

These methods have all been developed for function space in this and the preceding paper. Applications to special problems may be made in general by analogy to the ordinary 3-dimensional case.

Practical geometrical intuitions are developed by selecting from among all aspects of each geometrical figure those which are invariant. In Hilbert space, we have found that the angle between two lines and the length of a line are independent of the point of view. These invariant properties form a backlog of geometric intuition for function space, to which other more specialized intuitions may be added by studying many aspects of many geometrical figures. A few examples will be included in the following paper.

MATHEMATICS.—*Intuitive and descriptive geometry of function space: Geometric configurations.*[1]   MERLE RANDALL, Department of Chemistry, University of California, and BRUCE LONGTIN, Department of Chemistry, Illinois Institute of Technology. (Communicated by FREDERICK D. ROSSINI.)

In two preceding papers[2,3] a graphical representation of spaces of an indefinite number of dimensions was developed, together with the concepts of Euclidean projection and rotation, which are fundamental to the descriptive geometry of such a space. In this paper the application of these methods to actual problems of descriptive geometry is indicated.

The analytic geometry of a number of relatively simple n-space figures has been well studied.[4] A number of these results will be needed in order to obtain a graphical representation of these figures.

CURVED LINES AND SURFACES

A space curve may be represented analytically either as the intersection of two surfaces, or by means of parametric equations that express the various coordinates as functions of a single parameter, s (e.g., the curvilinear distance from a fixed point on the curve). The analytic representation of an m-dimensional hypersurface is most readily obtained by expressing the n coordinates in terms of m independent parameters (i.e., the m parameters of the surface). These parametric equations are of the form

$$v_i = f_i(t_1, t_2, \cdots, t_m); \quad i = 1, 2, \cdots, n \tag{1}$$

in which $t_1, t_2, \cdots, t_m$ are the m different parameters. Passing to the case of function space, equation 1 becomes

$$v(x) = f(x; t_1, t_2, \cdots, t_m). \tag{2}$$

The points along a curve in function space are represented by curves of a 1-parameter family, $v(x; t)$. Two-dimensional principal projections of such a curve are obtained by plotting $v(x_1; t)$ and $v(x_2; t)$ as
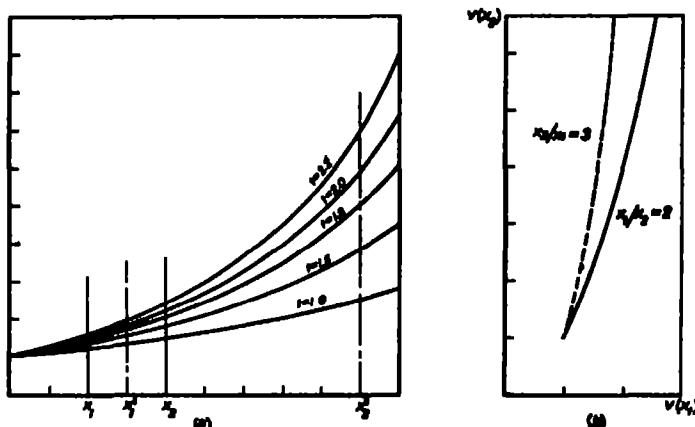
Fig. 1 —Representation and two principal projections
of a function space curve

the two Cartesian coordinates of the projection of a point of the curve. For example, if the equation of the curve is $v(x) = e^{xt}$, the equation of each principal plane projection is of the form $v(x_2) = [v(x_1)]^{(x_2/x_1)}$. In Fig. 1a each curve for a particular value of t represents one point on the function space curve. The whole function space curve is represented by a family of curves with different values of t. Each of these points may be projected on the plane whose indices are x_1 and x_2 by the method described in the first paper.[5] Fig. 1b shows two principal projections of the curve, one onto the plane $x_1 x_2$, and the other onto the plane $x_1' x_2'$. They were obtained graphically from Fig. 1a, and are seen to be members of a parabolic family.

A 3-dimensional principal projection of the curve is obtained in the same manner, using three values $v(x_1; t)$, $v(x_2; t)$, $v(x_3; t)$ as coordinates. It would appear as a space curve, each of whose three principal plane projections is one of the family of principal plane projections of the function space curve.

[5] RANDALL and LONGTIN.   Op. cit.

The points on a function space curved surface are represented by curves of a 2-parameter family, $v(x; t_1, t_2)$. An example is the representation of a plane, which was discussed in the first paper.[b] Each principal 3-dimensional projection of such a surface is obtained (Fig. 2) by plotting the points $[v(x_1; t_1, t_2), v(x_2; t_1, t_2), v(x_3; t_1, t_2)]$. In general, since two parameters are involved, the resulting projection is a curved surface in a 3-space. The principal plane projections are obtained by plotting only two of the three coordinates and are therefore principal projections of the curved surfaces.
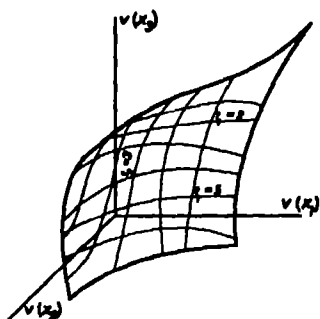
FIG. 2.—A principal projection of a function space curved surface

The points of a curved 3-space are represented by a 3-parameter family of curves in the function space diagram. Each principal projection onto a 3-space is a 1-parameter family of surfaces $[v(x_1; t_1, t_2, t_3), v(x_2; t_1, t_2, t_3), v(x_3; t_1, t_2, t_3)]$. Each surface of the family is a contour of the curved space for which t_3 (or some function of t_1, t_2, and t_3) is constant. The representation of a curved hypersurface of more than three dimensions by means of space projections is difficult. It can only be obtained by plotting contours of the figure, analogous to the representation of a 4-dimensional figure on a plane by means of 2-dimensional contours of the figure.

Views other than the principal projections may be obtained by rotation of axes. Each of the functions $v(x; t_1, t_2, \quad , t_m)$ corresponding to particular values of $t_1, t_2, \cdots, t_m)$ is expressed in terms of the rotated axis system by Fourier expansion, and then a series of principal projections is taken.

<center>SURFACES LYING IN A HYPERPLANE</center>

If the curved hypersurface is limited to an oblique plane hyperspace, its equation will be of the form

$$v(x; t_1, t_2, \cdots, t_m) = v_0(x) + t_1\epsilon_1(x) + t_2\epsilon_2(x) + \cdots + t_m\epsilon_m(x)$$

$$f_1(t_1, t_2, \quad \cdot\ , t_m) = 0$$

$$f_2(t_1, t_2, \qquad , t_m) = 0$$

$$\cdots \cdots \cdots$$

$$f_k(t_1, t_2, \qquad , t_m) = 0, \tag{3}$$

where the functions $\epsilon_i(x)$ are orthonormal and lie in the particular hyperspace in which the curved surface lies. Since there are only $(m-k)$ independent parameters, the curved surface has $(m-k)$ dimensions, and lies entirely in an m-dimensional space.

A projection of such a curved surface onto a space parallel to that in which it lies[6] is obtained by plotting the parameters $t_1, t_2, \cdots, t_m$, as coordinates.[6] These coordinates must satisfy the k equations $f_i(t_1, t_2, \cdots, t_m) = 0$. A projection of $v(x; t_1, t_2, \cdots, t_m)$ onto the space of $E_1(x), E_2(x), \cdot\quad, E_m(x)$ (the set $E_i(x)$ being orthonormal, but oblique to the set $\epsilon_i(x)$ is given as

$$v_E(x, t_1, t_2, \qquad , t_m) = v_{0E}(x) + t_1\sum_j \epsilon_{1j}E_j(x) + t_2\sum_j \epsilon_{2j}E_j(x)$$

$$+ \quad \cdot \quad + t_m\sum_j \epsilon_{mj}E_j(x) \tag{4}$$

$$= v_{0E}(x) + \sum_j (t_1\epsilon_{1j} + t_2\epsilon_{2j} + \qquad + t_m\epsilon_{mj})E_j(x),$$

in which $v_{0E}(x)$ is considered as the Fourier expansion of $v_0(x)$ in terms of the set $E_i(x)$ and ϵ_{ij} is the Fourier coefficient of $E_j(x)$ in the expansion of $\epsilon_i(x)$. The projection of the curved surface is found by plotting the m coefficients $s_j = (t_1\epsilon_{1j} + t_2\epsilon_{2j} + t_3\epsilon_{3j} + \cdots + t_m\epsilon_{mj})$ as m Cartesian coordinates,[6] while requiring that the parameters $t_1, t_2, \cdots,$ t_m satisfy equations 3. Since the coefficients ϵ_{ij} are constants depending on the relative direction of the original and the projection space, the coordinates in the projection are simply linear combinations of the parameters t_i.

HYPERSPHERE LIMITED TO AN m-SPACE

If the surface considered is a hypersphere of $(m-1)$ dimensions, then $k = 1$, and the single equation restricting the parameters is

$$t_1^2 + t_2^2 + \qquad + t_m^2 = r^2, \tag{5}$$

r being the radius of the hypersphere. From the theory of bilinear forms it is found that if the functions $E_j(x)$ are chosen to give the

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[6] This operation implies that the origin in the projection plane is chosen at a point which represents the projection of $v_0(x)$.

proper orientation of the vectors $\mathbf{E}_j$ in the projection space, the coordinates $s_j = \sum_i t_i e_{ij}$ must satisfy an equation of the form

$$\sum_j (a_j s_j)^2 = r^2 \tag{6}$$

in which the coefficients a_j depend on the angle between the projection space and the space of the sphere. Equation 6 shows that the projected figure is an m-dimensional ellipsoid (or $(m-l)$-dimensional if l of the vectors e_i are orthogonal to the projection plane: this gives an l-edgewise view of the sphere). The orientation of the vectors $\mathbf{E}_i$ is chosen to coincide with the principal axes of the ellipsoid.

POLYNOMIALS IN FUNCTION SPACE

In spaces of a finite number of dimensions the simplest analytic $(n-1)$ dimensional figures are those whose equations are of the form $P(v_1, v_2, \cdots, v_n) = 0$, the function P being a polynomial in the n coordinates $v_1, v_2, \cdots, v_n$.

The homogeneous polynomial of degree m in the n variables may be expressed as

$$P_m(v_1, v_2, \cdot \quad , v_n) = \sum_{i,j, \cdots, p} (v_i v_j \quad v_p) a_{i,j, \cdot \quad , p,} \tag{7}$$

the multiple summation being extended over m indices. If each of the indices covers all values n, each of the combinations $(v_i v_j \quad \cdot v_p)$ will occur $\lfloor n$ times, once for each permutation in which the m indices may appear in the product.

If the coordinates $v_1, v_2, \cdots, v_n$ are components of the vector $\mathbf{v}$ expressed in terms of the orthonormal base vector system, then each of them must be expressed as $v_i{}'(dx_i)^{1/2}$ in terms of the reduced base vector system. In order to pass from the finite case to function space, it is necessary to assume that each $a_{ij \cdot \ p}$ is equal to $a'_{ij \cdot \ p} (dx_i dx_j \cdots dx_p)^{1/2}$. Then in the limit, the homogeneous polynomial becomes

$$P_m \left| [v(x)] \right| = \int_\Delta^{(m)} a(x_i, x_j, \quad , x_p)' v(x_i)' v(x_j)' \cdot \quad v(x_p)' dx_i dx_j \quad dx_p. \tag{8}$$

Since each product $[v(x_i)' v(x_j)' \cdots v(x_p)']$ corresponding to a particular set of values of $(x_i, x_j, \cdots, x_p)$ may appear several times, not all sets of functions $a(x_i, x_j, \cdots, x_p)$ will generate distinct polynomials.

The homogeneous polynomial of equation 8 may take certain special forms. If $a(x_i, x_j, \cdots, x_p)$ has the value $1/(dx_i dx_j \cdots dx_{p-1})$ when $x_i = x_j = \cdot \quad \cdot = x_p$, and zero for all others sets of values of $(x_i, x_j, \cdots, x_p)$, then

$$P_m \left| [v(x)] \right| = \int_a^{a+\Delta} a(x)'[v(x)]^m dx. \tag{9}$$

When $a(x_i, x_j, \cdots, x_p)$ has other less severe singularities, the polynomial may reduce to the form

$$P_m \left| [v(x)] \right| = \int_\Delta^{(k)} a(x_i, x_j, \quad , x_p)[v(x_i)]^b[v(x_j)]^c \qquad [v(x_p)]^g \tag{10}$$
$$dx_i dx_j \qquad dx_p$$

where k is less than m, and $(b+c+\cdots+g)$ is equal to m.

The general mth order polynomial is expressed as

$$\overset{m}{P} \left| [v(x)] \right| = \sum_{i=0}^{m} P_i \left| [v(x)] \right|, \tag{11}$$

the term for $i = 0$ being a constant. The equation $\overset{m}{P}\left| [v(x)]\right| = 0$ then represents a general type of hypersurface analogous to the ordinary case $P(v_1, v_2, \cdots, v_n) = 0$. The most general equation of a hypersurface in function space is

$$F \left| [v(x)] \right| = 0, \tag{12}$$

where F is any functional whatever. This corresponds to the ordinary case $f(v_1, v_2, \cdots, v_n) = 0$.
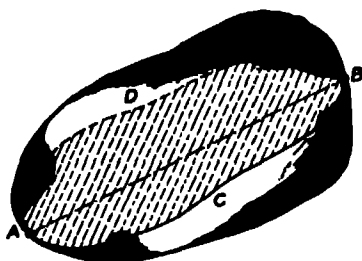
Fig. 3 —Sections of a 3-dimensional solid.

PLANE AND SOLID SECTIONS OF A HYPERSURFACE

In the descriptive geometry of 3-space it is necessary to represent a curved surface by means of contours, which are parallel plane sections of the solid figure. Some idea of the n-dimensional figure may be obtained in a similar manner by projection of two 3-dimensional sections of the figure onto 2- and 3-spaces.

In so doing, it must be remembered that in the 3-dimensional case a plane cuts the surface in a curve (curve $ACBD$ in Fig. 3), while a straight line cuts it only in one or more isolated points (A and B). If

the surface is closed, the curve more or less surrounds the surface while the points do not. Furthermore, if the directions of the line and plane are fixed, the plane may be located by fixing one parameter while to locate the line requires the fixing of two parameters. In function space the 2- and 3-dimensional sections are analogous to the linear rather than the plane section of Fig. 3.

The general solid section of the figure represented by equation 12 is obtained when the function $v(x)$ lies in a particular 3-space,

$$v(x) = v_0(x) + t_1\epsilon_1(x) + t_2\epsilon_2(x) + t_3\epsilon_3(x), \tag{13}$$

where t_1, t_2, and t_3 are parameters independent of x and $\epsilon_1(x)$, $\epsilon_2(x)$, $\epsilon_3(x)$ are orthogonal functions lying in the chosen 3-space. The equation of the section is therefore

$$F \mid [\{v_0(x) + t_1\epsilon_1(x) + t_2\epsilon_2(x) + t_3\epsilon_3(x)\}] \mid = 0. \tag{14}$$

When the figure is a "polynomial" surface, the equation of a solid section becomes fairly simple. When the function $v(x)$ lies in the space defined by equation 13, the homogeneous polynomials become

$$P_m \mid [\{v_0(x) + t_1\epsilon_1(x) + t_2\epsilon_2(x) + t_3\epsilon_3(x)\}] \mid$$

$$= \sum (t_1^b t_2^c t_3^d) \int_\Delta^{(m)} a(x_i, x_j, \quad , x_p)' \tag{15}$$

$$[v_0(x)]^{(g)} [\epsilon_1(x)]^{(b)} [\epsilon_2(x)]^{(c)} [\epsilon_3(x)]^{(d)} dx_i dx_j \quad dx_p$$

where the brackets $[v_0(x)]^g$ etc. represent the products of g factors of the form $v_0(x_i)$ etc., and the sum $(b+c+d+g)$ is equal to m. Hence the general polynomial $\bar{P} \mid [v(x)] \mid$ becomes a general polynomial in the parameters t_1, t_2, and t_3 when $v(x)$ lies in the given 3-space. The constant coefficients in this polynomial are sums of integrals of the form which appears in equation 15.

The solid sections of a figure by the 3-space of equation 13 is to be found by plotting the parameters t_1, t_2 and t_3 as Cartesian coordinates. Thus the solid sections of a polynomial hypersurface of degree m are found to be "polynomial" solids of degree equal at most to m. That is, the equations of the sections are of the form $P(t_1, t_2, t_3) = 0$, where P is a polynomial of degree equal at most to m.

<center>HYPERSPHERE IN FUNCTION SPACE</center>

The vector v defines a point in the hypersphere of radius R, if its length is constant and equal to R. Hence the equation of the hypersphere is

$$\int_\Delta [v(x)]^2 dx = R^2. \tag{16}$$

Taking a section by the plane of equation 13, we find

$$l_1{}^2 + l_2{}^2 + l_3{}^2 + |v_0|^2 = R^2 \tag{17}$$

provided $v_0(x)$ is taken orthogonal to $\epsilon_1(x)$, $\epsilon_2(x)$, and $\epsilon_3(x)$ (which is always possible).

Equation 17 is the equation of a sphere of radius $(R^2 - |v_0|^2)^{1/2}$, $|v_0|^2$ being the distance from the cutting 3-space to the center of the sphere.

If these successive sections (corresponding to a series of values of $v_0 = p\hat{v}_0$ in which only a single parameter, p, is varied) are all projected on a space parallel to the cutting spaces, they will appear as a series of concentric spheres of which the largest has the radius R. If instead the projection is taken onto a space oblique to the cutting spaces, the sections will appear as a series of similar ellipsoids (cf. equation 6) whose centers lie at points which are the projections of v_0.
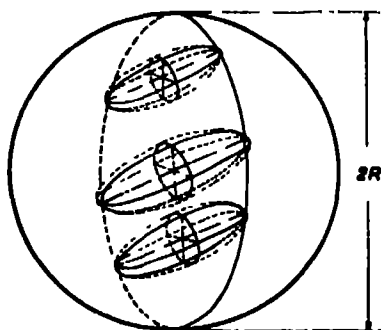
Fig 4 —Projected sections of a hypersphere.

A series of such sections is shown in Fig. 4. They are each shown as twice tangent to a sphere of radius $2R$ (a view of the great sphere which is parallel to the projection space), the locus of the points of tangency being a great circle of the sphere. This is an intuitive generalization of the analogous case in which circular sections of a sphere appear in two dimensions as ellipses tangent to a circle of radius $2R$. The proof would result from an application of the theory of bilinear forms. Different choices of the vector $\hat{v}_0$ would give other than great circle loci of the points of tangency. Particular directions of the projection space might cause the ellipsoid to become tangent to the great-sphere in a small (or great) circle.

<center>PROJECTED DENSITIES</center>

Imagine a nonrefractive, nonreflecting translucent sphere. This sphere appears in a single view as a circular region, which is densest
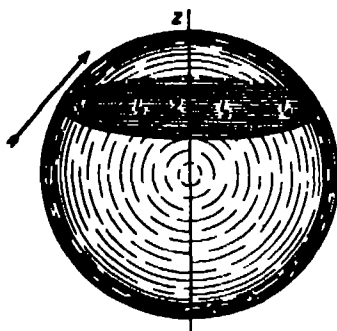
Fig 5 —Illustration of significance of projected density

near the center and quite attenuated at the circumference. The apparent density at each point is proportional to the length of linear segment of the sphere, of which the point is an end-on view. For example, in Fig. 5 the segments l_1, l_2, l_3, and l_4 are parallel to the projection rays. Each appears as a point that has a density proportional to its length. This is the projected density of the sphere at this point.

If the projection is taken onto the axis Z rather than onto a plane, all the points in a plane normal to Z appear in the single point Z_1, of density proportional to the area of a plane section of the sphere. This is the projected density of the sphere in terms of a line or 1-dimensional-projection.
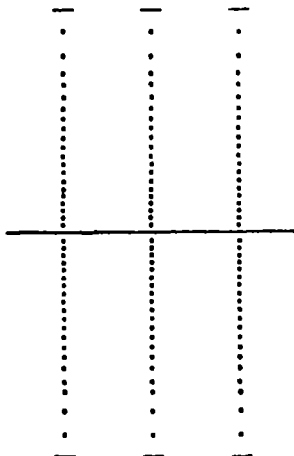
Fig 6 —Density projections of 3-dimensional sphere on 3-principal axes.

By equation 17, the $(n-1)$ dimensional section of a hypersphere by a space which is distant $|v_0|$ from the center of the sphere has a radius

$$r = (R^2 - |v_0|^2)^{1/2}. \tag{18}$$

The volume of this sphere is proportional to $r^{(n-1)}$. Levy[7] has shown that this volume becomes either zero or infinite, depending on whether r is less or greater than $[(n-1)/2\pi e]^{1/2}$.

The largest of these sections is the great sphere whose radius is R, corresponding to a value of $|v_0|^2$ of zero. If V_0 and V are the volumes of the great sphere, and of any small sphere respectively, then

$$V/V_0 = \lim_{n \to \infty} [1 - (|v_0|/R)^2]^{\frac{n-1}{2}}$$

$$= \exp [- (|v_0|/R)^2(n - 1)/2]$$

(19)

This ratio is greater than zero only if $|v_0|$ is of the order of $R/(n-1)^{1/2}$.

In any projection of the hypersphere onto a straight line, the projected density is infinitely greater at the center than at any other point. It decreases exponentially with the distance from the center, and becomes almost zero at an infinitesimal distance from the center. It becomes exactly zero at a distance of R from the center.
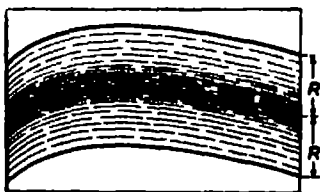
Fig. 7 —Projected density of an n-dimensional hypersphere in the function space diagram.

Fig. 7 shows the projections of the density of an n-sphere onto each of the principal axes, arranged to form a function space diagram. The density decrease in receding from the center is shown less abrupt than the actual case, for the purpose of representation. This density distribution may also be considered as the result which would be obtained by superposing all curves $v(x)$ having lengths less than R as measured from the center of the sphere. It is a composite function space diagram of all vectors which determine points within the sphere, and, as such, may be used to represent the sphere.

OTHER ANALYTIC FIGURES

Other n-dimensional figures may be studied in the same manner, by means of sections and projected densities. For example, the hyperellipsoid whose equation is

$$\int_\Delta [v(x)/a(x)]^2 dx = 1$$

(20)

[7] LEVY, P.   Op cit

has principal axes equal to $a(x)$. All its representations may be obtained from those of the sphere by magnifying the various axes in the proportions $a(x):R$. The projected density diagram is shown in Fig. 8.
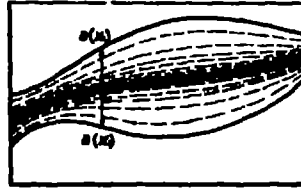
Fig. 8.—Projected density of an n-dimensional hyperellipsoid in the function space diagram

Of all the sections of a function-space figure, the most interesting is the section that appears greatest in any particular projection. This corresponds to the outline in a 2-dimensional view of a solid figure and is represented by the great-sphere in the case already discussed. In particular cases it may be found by analytic or intuitive methods. In general it is found by trial, from the construction of a large number of sections.

RECTANGULAR HYPERPARALLELOPIPED

If we interpret the vector equation

$$(h + l) \geqq v \geqq h \tag{21}$$

to mean that each of the components v_i lies between the limits h_i and $(h_i + l_i)$ and may be equal to either limit independent of whether any other component lies at its limit, then the vector v traverses all points interior to (and on the surface of) a rectangular parallelopiped. If v_i is
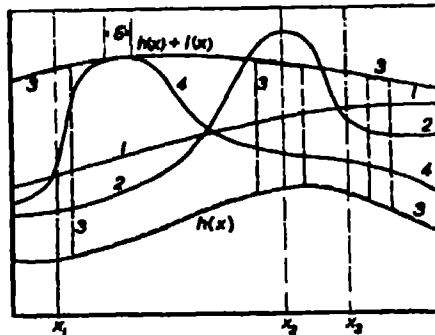
Fig 9.—Function space diagram of a rectangular hyperparallelopiped

equal to h_i, and none of the other components lies at either of its limits, the vector $\mathbf{v}$ traverses a limited rectangular portion of an $(n-1)$ dimensional hyperplane—one of the faces of the parallelopiped. When v_i is equal to (h_i+l_i), $\mathbf{v}$ traverses the opposite face. Hence the "reduced" length of the side normal to these faces is l_i. The parallelopiped has its edges parallel to the coordinate axes. They are respectively equal to the components of 1. Its corner which is nearest the origin lies at the end of $\mathbf{h}$.

Fig. 9 shows the function space diagram for a hyperparallelopiped. The curves $h(x)$ and $h(x)+l(x)$ represent the vectors $\mathbf{h}$ and $\mathbf{h}+\mathbf{l}$. Curve 1 represents a point entirely interior to the parallelopiped. Over a portion of the interval Δ, curve 2 passes outside the limit of $h(x)+l(x)$, and hence represents a vector which does not satisfy equation 21. It represents a point outside the parallelopiped. Curve 3 represents a function all of whose values are equal to one or the other of the limits. Hence it represents a vertex of the parallelopiped. The curves $h(x)$ and $[h(x)+l(x)]$ represent two opposite vertices. Curve 4 has $(n\delta/\Delta)$ of its components equal to their respective upper limits. It represents a point which lies in a $(1-n)\delta/\Delta$-dimensional face of the parallelopiped.

If the function $l(x)$ is constant independent of x, the vector $\mathbf{l}$ being equal to $le'_a{}^{a+\Delta}$, the parallelopiped becomes a hypercube. Hence the hypercube is represented by curves, $v(x)$ which lie entirely within the region bounded by two curves, $h(x)$ and $[1+h(x)]$, which are vertically equidistant for all values of x.
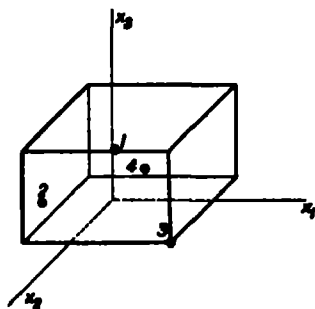
Fig 10 —Principal projection of Fig 9 on the x_1-x_2-x_4-space.

Fig. 10 shows a principal projection of the parallelopiped of Fig. 9. It is seen as a rectangular parallelopiped in three dimensions. In any principal m-dimensional projection of the figure, the coordinates must each satisfy an inequality $(h_i+l_i) \geqq v_i \geqq h_i$, and hence all the

projected points must lie inside a rectangular parallelopiped. The projection appears as this parallelopiped.

Oblique views and sections of the parallelopiped may be obtained in the manner already described for analytic surfaces. A consideration of the spheres inscribed and circumscribed in a hypercube will indicate the difficulties involved. The radius of the inscribed sphere has a length equal to $\frac{1}{2}l(\Delta/n)^{1/2}$ in terms of the unit base vector system (the length of a side of the cube is $l(\Delta/n)^{1/2}$ in terms of this system). The radius of the circumscribed sphere is half the length of the long diagonal, which is $l|e'_{a}{}^{a+\Delta}| = l$. If the circumscribed sphere is of finite radius, the inscribed sphere has an infinitesimal radius.
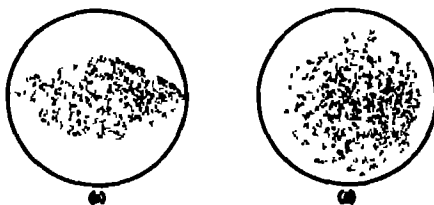
Fig 11 —Projections of the vertices of a hypercube.

The cube has 2^n vertices which must lie in the surface of the circumscribed hypersphere. In the projection they will appear scattered irregularly throughout the interior of the bounding great-sphere, the distribution depending on the orientation of the projection space. No two vertices lying on the same edge may appear in the projection at a distance greater than $l(\Delta/n)^{1/2}$ (i.e., the length of the edge on which they lie), which is infinitesimal. Hence the distribution of vertices will be macroscopically dense in certain regions of the projection. If the projection is edgewise to a number of dimensions of the hypercube, the region may be limited by a surface which is tangent to the projection of the inscribed sphere [the greatest breadth observed in the projection along the direction normal to the edgewise faces is equal to the length of a side]. In other cases the vertices will more nearly appear to fill the great-sphere boundary of the circumscribed sphere. Fig. 11a shows a conceivable nearly edgewise view, while Fig. 11b is less nearly edgewise to any of the faces.

In the special case of a finite number of dimensions, the various oblique views are more simply described. The number of vertices is finite, while the edges appear to have finite rather than infinitesimal lengths. The resulting figures are common in treatises on polytopes.

SUMMARY

Regions of function space having one dimension (curved line) and two dimensions (curved surface) are easily represented in the function-space diagram by a family of curves having one or two parameters, respectively. In any 3-space projection they appear as a curved line or curved surface.

Any figure having more than three dimensions is of course difficult to represent in a space of three dimensions. The problem is like that of representing a solid figure on paper. Three methods have been illustrated, namely:

1. The projected outline of the figure.
2. The projected sections or contours.
3. The projected density.

A fourth method commonly used in descriptive solid geometry is that of the illuminated and shaded surface. While this method often gives the most clearly readable representation of solid figures, its application to function space is questionable, since the laws of illumination and reflection are not known for more than three dimensions.

ZOOLOGY.—*A review of the subspecies of the indigo snake* (Drymarchon corais).[1] HOBART M. SMITH, Smithsonian Institution. (Communicated by HERBERT FRIEDMANN.)

In the most recent study of *Drymarchon* (Amaral, Mem. Inst. Butantan 4: 323–330, 1929), three subspecies of the monotypic genus are recognized: *corais corais, corais melanurus,* and *corais couperi.* The last named is stated to range "from northeastern Mexico to southeastern United States." As has been shown by Blanchard (Papers Michigan Acad. Sci., Arts and Lett. 4: 28, 1925), and accepted by Stejneger and Barbour (Check List N. Amer. Amph. Rept., ed. 4, pp. 106–107, 1939), the form in Florida and Georgia possesses characters in both coloration and scutellation that differentiate it from any other population of the genus; and to this form must be applied the name *couperi,* with type locality in Georgia. Present records further demonstrate that there is a hiatus between the range of *couperi* and that of the *Drymarchon* of Texas, this hiatus occurring in the region of Louisiana, eastern Texas, and Mississippi.

Amaral (*op. cit.*) indicates that the area of intergradation between his composite *couperi* and his *melanurus* of Central America and central Mexico may occur in the region of Tamaulipas and Veracruz. Since it can be demonstrated that the southwestern Texas form of

Drymarchon is not *couperi*, the identity of the forms that are inferred to intergrade in Mexico is left in doubt.

This confusion has led to a reexamination of specimens in the U. S. National Museum and in the EHT-HMS collection and to an attempt to redefine the various forms of the genus. In the United States and South America the problem seems relatively simple, as only two well-defined forms in each area are represented by specimens examined. In Mexico and northern Central America, however, the problem becomes complicated. Five of the seven recognizable forms occur in this area. Lack of adequate material of certain subspecies has hampered a ready understanding of the variation and distribution of all forms. Most difficult to handle of all are the young, which are frequently unidentifiable. With more material, accompanied by specific locality data, probably the difficulties encountered in separating the young may be eliminated. The young of three forms are definitely identifiable, through their peculiar scutellation or coloration, or both. Those of the other four forms can be separated into two groups, but association with either one of the two subspecies in each group is now too vague to be reliable—other than by geographic probability.

I am indebted to Dr. E. H. Taylor for his suggestions and loan of material during the course of this study, which was begun some time ago at the University of Kansas. An important portion of the material utilized was collected and studied during my tenure of the Walter Rathbone Bacon Traveling Scholarship of the Smithsonian Institution.

KEY TO THE FORMS OF DRYMARCHON

1. Belly and tail light throughout their length, no *distinctive* dark marks on edges of subocular labials; in adults, anterior portion of body darker than posterior portion and tail   *corais corais*
   Tail and at least posterior part of belly usually dark (black), if not, distinctive dark marks present on edges of at least subocular labials   2
2. Antepenultimate labial separated from temporals by contact of adjacent supralabials, all black except chin and sometimes a few areas on supralabials; caudals less than 68, ventrals 185 to 189 in males, 193 to 195 in females   *corais couperi*
   Antepenultimate labial in contact with temporals or lower preocular, or both .   .   3
3. Subcaudals less than 68 (55 to 65); ventrals 193 or less; scale rows usually 14 near anus   *corais erebennus*
   Subcaudals more than 68 (69 to 83), scale rows usually 15 near anus   4
4. Anterior portion of body light brown, extreme posterior portion and tail black; three vertical black streaks on posterior edges of subocular labials, and one on posterior edge of seventh labial, never any on preocular labials (either above or below); lateral gular scales never black-tipped; young lighter anteriorly than posteriorly, like adults, but with very broad, light, chevron-shaped bands covering two scale lengths .
   .   .   .   .   *corais melanocercus*

Entire body and tail light brown above, or all black; light bands in young specimens narrow, covering about one scale length (?)........ .. 5
5. Entire body brown above, and no darker posteriorly than anteriorly; ventral surface of tail and posterior portion of body dark, but not black; young (and some adults) with distinct, longitudinal, short black streaks on anterior part of body   ....*corais unicolor*
Entire body nearly uniform black above; belly black on posterior portion, subcaudal surface black   6
6. Light areas on supralabial region white or cream, very sharply defined from the black borders; anterior portion of belly mostly light, salmon pink in color   .   .   .   *corais rubidus*
Most of head, including sides, black; most of belly black, the light portions cream or white, not reddish   .   *corais orizabensis*
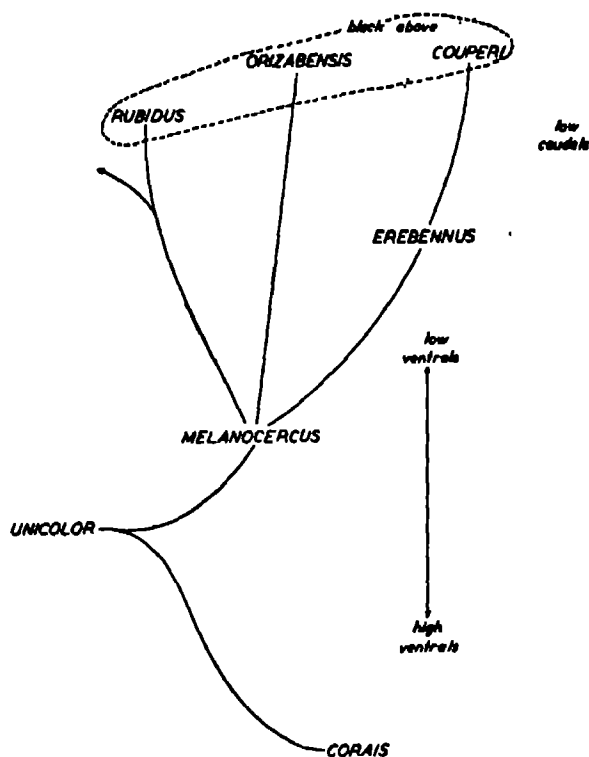
Fig 1.—Possible phylogeny of the subspecies of *Drymarchon corais*

Evolution within the genus may be traced by the general trend toward melanism in end forms, as in *couperi, rubidus,* and *orizabensis.* Accordingly a form that is the least melanistic is indicated as the more primitive; this form is *unicolor.* The geographically centralized position of *unicolor* in relation to others supports the premise that it is the most primitive. Evolution has proceeded in two directions from this common ancestor, both geographically and in pattern. In one direc-

tion, toward the south, evolved *corais*, now restricted to South America. This branch exemplifies a different trend in pigmentation than does the other branch—progression of melanism from the cephalic region toward the tail. The trend in the second branch is from the tail toward the head. In both branches pattern evolution is directed toward an end form completely black in color.
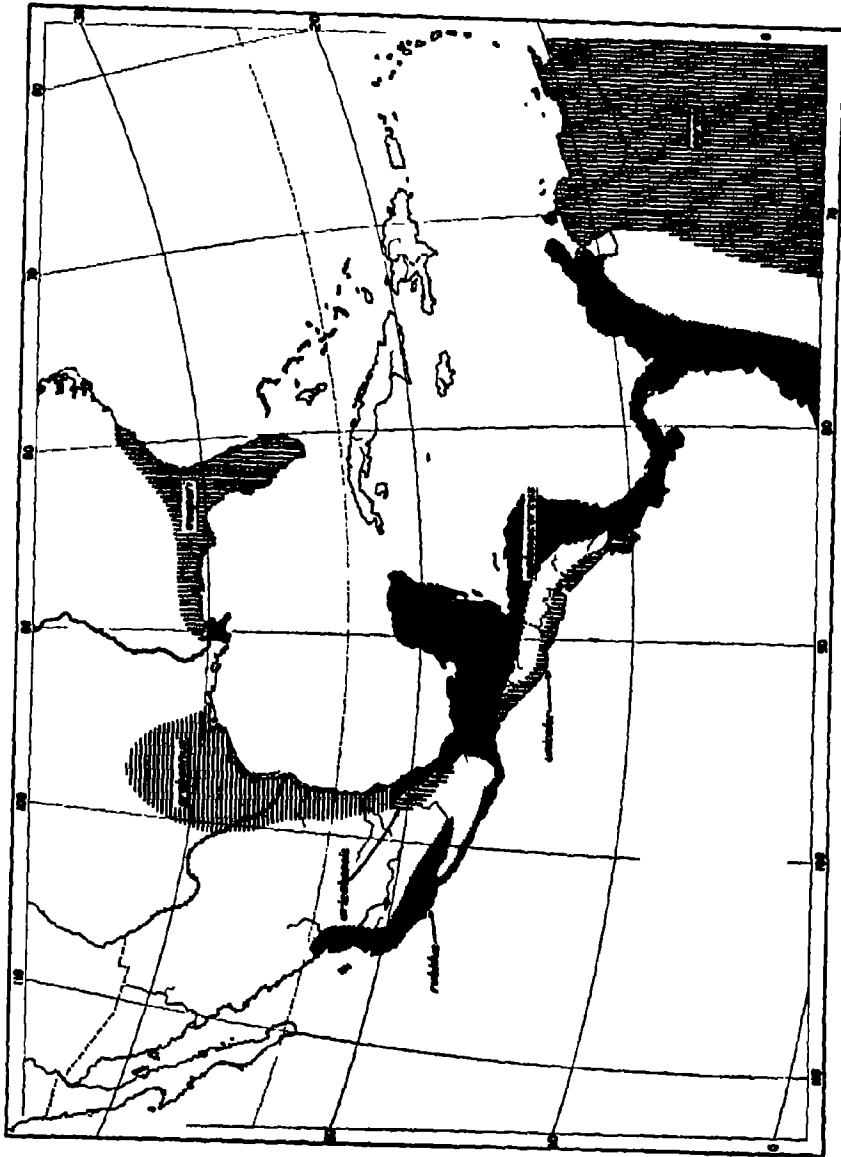
Fig. 2 — Distribution of the subspecies of *Drymarchon corais*. Base map courtesy McKnight and McKnight.

The fact that *unicolor* is now widely separated from *corais* by *melanocercus* in Costa Rica, Panama, and northern South America does not prove the former could not have given rise to *corais*. It is very unlikely that, once the tail-head tendency of pattern change was established in *melanocercus*, it should be reversed to produce the characters now shown by *corais*.

Development of other forms in the genus appears to have proceeded solely from *melanocercus*. While *unicolor* extends a considerable distance toward the north on the Pacific slope, it is separated from *melanocercus* the whole distance by the central mountain ranges. Near the Isthmus, however, where the mountain ranges are lower and complete connection between the Atlantic and Pacific coast populations is possible, the two forms again come in contact, but the more plastic of the two (*melanocercus*) has changed, as in this region it is intergrading with *rubidus* of northern Pacific slopes; perhaps because of this change in *melanocercus* there is no mingling of *unicolor* with it in this area; the two live in the same general region in southern Chiapas, and the ranges may overlap to a still greater extent than now known.

It is apparent, then, that it was *melanocercus*, not *unicolor*, that gave rise to *rubidus*. The *rubidus* stem produced no further subspecies, except perhaps one on the Tres Marias Islands.

On the Atlantic coast *melanocercus* gave rise to another color phase (*orizabensis*) very much like *rubidus*; these two are conceived as parallel developments not derived one from the other. Still farther north *melanocercus* gave rise to *erebennus*; and presumably the latter to *couperi*, since these two hold in common a caudal count lower than that of other forms.

It should be observed that all three end forms (*rubidus*, *orizabensis*, *couperi*) of the *melanocercus* branch of *Drymarchon* (as opposed to the *corais* branch) are very black; two of them (*orizabensis*, *couperi*) are practically uniform black; and one of them (*couperi*) not only has reached the ultimate stage in color evolution in the genus, but is by far the most highly modified in scutellation. The expectation, of course, is that the *corais* branch should possess one or more black subspecies; if they exist, however, they are not yet known.

Drymarchon corais unicolor subsp. nov.

Holotype.—U.S.N.M. no. 110865, female, from La Esperanza, near Escuintla, Chiapas

Paratypes.—U.S.N.M. nos. 6757A-B, "Guatemala"; no. 12687, Escuintla, Guatemala; no. 79960, Managua, Nicaragua; no. 46464, Huehuetan, Chiapas; no. 30424, "Tehuantepec"; and EHT-HMS (HMS 14556) from Colonia Hidalgo, 8 kilometers north of La Esperanza, Chiapas.

Diagnosis.—Adults uniform light brown above, posterior portion no or little darker than anterior, sometimes longitudinal black streaks anteriorly; venter light, becoming somewhat darker posteriorly and under tail, but not black; young with short, black streaks anteriorly, posteriorly with narrow, irregular, light crossbars. Ventrals 192 to 206; caudals 70 to 77 (females); totals 266 to 281 (females). Antepenultimate labial in contact with temporals of postoculars, or both; scale rows posteriorly usually 15

Description of holotype.—Head scales normal; supralabials eight, the sixth in contact with lower anterior temporal; infralabials nine, first five in contact with chin shields, four in contact with anterior chin shields, one preocular, two postoculars; temporals in two rows, three in lower row, two in upper; lower posterior temporal narrowly in contact with parietal on one side (between the two upper temporals), narrowly separated on the other; posterior chin shields distinctly shorter and smaller than anterior; ventrals 195; anal entire; caudals 71 Total length 1570 mm, tail 320 mm

Dorsal surface of entire body and tail uniform light brown, with the exception of irregular, short, poorly defined, diagonal black streaks on anterior portion of body; a black, diagonal patch on nape, poorly defined and short. Sides of head light brown, as dorsal surface, a vertical black mark on the posterior edge of the fourth to the seventh supralabials, and on the corresponding infralabials; posterolateral gular scales darker at their tips.

Belly light anteriorly, posterior fifth becoming brown, as subcaudal surface; no portion of belly or tail black, save a very few marks on the edges of some ventrals.

Variation.—The paratype series compares well with the holotype in coloration. In one the dark streaks are more prominent In none is the posterior portion of the belly, or the subcaudal surface, black

TABLE 1 —SCALE COUNTS IN UNICOLOR

Number	Sex	Ventrals	Caudals	Scale rows	Supra-labials	Antepenultimate labial
6757	♂	200	68 +	17–15	8–8	Contact
6757	♀	204	77	17–15	8–9	Contact
30424	♀	192	75	17–15	8–8	Contact
12687	♀	199	71	17–15	8–8	Contact
46464	♀	200	70	17–15	8–8	Contact
79960	♀	204	75	17–15	8–8	Contact
110865	♀	195	71	17–15	8–8	Contact
14556	♀	200	52 +	17–15	8–8	Contact

Remarks.—Almost certainly this form intergrades with *melanocercus* in southern Nicaragua or northern Costa Rica. The Managua, Nicaragua, paratype is fairly typical, however. North of Nicaragua the two forms do not intergrade, as they are separated by continuous, high ranges of mountains except toward the Isthmus of Tehuantepec Here they do not intergrade, either, as typical *unicolor* occurs at La Esperanza, Chiapas, with *melanocercus-rubidus* intergrades. An ecological segregation of the two types at La Esperanza is indicated The single intergrade secured there (No. 110874) as well as two intergrades from Tonalá, Chiapas (Nos 110875–6) were found in the forested hills, while the two *unicolor* collected near La Esperanza were found on the coastal plain. Presumably the latter subspecies occurs still farther north in the same habitat. Unfortunately no specimens are known from the coastal plain between the vicinity of Tehuantepec and La Esperanza.

The *rubidus-melanocercus* intergrades are further discussed in the description of the former subspecies.

Drymarchon corais corais (Boie)

Coluber corais Boie, Isis, 1827, p. 537; Schlegel, Essai Phys. Serp. 2: 139–141, pl. 5, figs. 9, 10. 1837.

Geophyas flaviventris Steindachner, Sitzb. Akad Wiss. Wien 55: 271, pl. 4, figs. 4–7. 1867 (Matogrosso, Cuyaba und dem Rio Vaupe).

Spilotes corais suborbitalis Peters, Monatsb. Preuss. Akad. Wiss., Berlin, 1868: 641 (Caracas, Venezuela).

Spilotes corais xanthurus Brown, Proc. Acad. Nat. Sci Philadelphia, 1893: 433 (type locality unknown; not Veracruz, as suggested).

Drymarchon corais corais Amaral, Mem. Inst Butantan 4: 325–327, pl. 1929.[2]

Type locality.—America.

Diagnosis.—Adults dark anteriorly, light posteriorly on back; belly and subcaudal surface white, except edges (lateral); young no darker anteriorly

TABLE 2 —SCALE COUNTS IN CORAIS

Number	Sex	Ventrals	Caudals	Scale rows	Supra-labials	Antepenultimate labial
5579	♀	208	72	17–15	8–8	Contact
5579	♀	209	75	17–15	8–8	Contact
11309	♀	210	—	17–15	8–8	Contact
12535	♂	205	83	17–15	8–8	Contact
15233	♂	202	80	17–15	8–8	Contact
60660	♂	—	79	17–15	8–8	Contact
60749	♂	206	82	17–15	8–8	Contact
66871	♀	210	74	17–14	8–8	Contact
84523	♀	205	74	17–15	8–8	Contact

than posteriorly, but with more or less chevron-shaped, broad, light bands, not interrupted and covering about two scale lengths; supraocular labials not distinctively black-edged (see below) in young or adult. Ventrals 190 (?) to 217 (males 190 to 210, females 205 to 217); caudals 72 to 84 (72 to 84 in males, 72 to 78 in females), total counts 272 to 292 (males 272 to 292, females 278 to 291). Antepenultimate labial in contact with temporals or postoculars or both; scale rows posteriorly usually 15.

Range.—"Northern Argentina, Paraguay, Bolivia, tropical Brazil, eastern Ecuador and Peru, the Guianas, Venezuela, Trinidad and Tobago" (Amaral, *loc. cit.*).

Specimens examined.—Ten, all in the National Museum: Nos. 5579A-B, 12535, 15233, Trinidad; nos. 60660, 60749, Santa Ana, Peru; nos. 66871, Moengo, Surinam, Dutch Guiana; no. 84523, Pomeroon, 70 miles from Georgetown, British Guiana; no. 11309, Brazil; no. 100756, Terenos, Matto Grosso, Brasil.

Remarks.—The body coloration of adults of this form is not duplicated in any other subspecies of the genus. Most distinctive is the white belly and

[2] *Phrynonax angulifer* Werner, included by Amaral (*op. cit*, p. 325) in the synonymy of *corais*, does not seem to belong to this genus It is said to have 21 scale rows; 224 ventrals; fourth, fifth, and sixth labials in contact with the eye; and the nine median scale rows keeled.

subcaudal surface, combined with a light dorsal surface on tail and posterior part of body. Also very strikingly different from other subspecies is the absence of distinctive dark marks on the posterior edges of the subocular labials. These are very characteristic of other subspecies (unless the whole top and side of head is black), but in *c. corais* are absent, although the edges of all dorsal and lateral head scales may be black; or the whole top of the head may be black, the color extending a little below the eye.

In addition to the data afforded by the 10 National Museum specimens, ventral and caudal counts of 44 others, given by Amaral (*loc. cit.*), have been available for establishing the limits of variation in these two characters.

Drymarchon corais melanocercus nom. nov.

Spilotes melanurus Duméril and Bibron, Erp. Gén. 7: 224. 1854.
Geoptyas collaris Steindachner, Sitzb. Akad. Wiss. Wien 55: 271, pl. 3, figs. 4–7 (Brazil). 1867.
Drymarchon corais melanurus Stejneger and Barbour (part), Check List N. Amer. Amph. Rept., ed 2: 94. 1923—Amaral, Mem. Inst. Butantan 4: 325, 330 (part). 1929.

Type locality.—"Mexico."

Diagnosis.—Adults light brown anteriorly, dark (black) on posterior fourth or fifth of body and on tail, both above and below; young generally a little lighter anteriorly than posteriorly, the bands (where visible, usually toward middle of body) similar to those of young *c. corais;* black marks on subocular labials very sharply defined, rest of head very light; no black marks on labials preceding orbit, nor on lateral gular scales; diagonal black mark on each side of neck very well defined Ventrals 191 to 214 (males 191 to 208, females 197 to 214); caudals 71 to 88 (males 71 to 88, females 71 to 80); totals 262 to 296 (males 272 to 296, females 268 to 279). Antepenultimate labial in contact with temporal or postocular or both; scale rows usually 15 posteriorly.

Range.—Pacific slopes of Peru and Ecuador, northern Colombia; Central America north to northern Veracruz on the Atlantic side, to southern Nicaragua on the Pacific side.

Specimens examined.—Fourteen. One in the EHT-HMS collection (no. 11636) is from Mérida, Yucatán The remainder, in the National Museum; are from VERACRUZ. Mirador? (no. 25093). CHIAPAS: Palenque (no. 110871); TABASCO: Tenosique (no. 110870). YUCATÁN· Chichen Itza (no. 46393); Yucatán (no. 6554). GUATEMALA (Petén): Pacomon (no. 71371), Piedras Negras (nos. 110872–3). COSTA RICA (no. 61947). PANAMÁ (no. 53629). Washington Station (no 8393) COLOMBIA: Cayo Papoyal, Bolivar Dist. (no. 54338). ECUADOR (no 14025)

Remarks.—This subspecies is remarkably well defined and uniform in character of color pattern throughout its entire range from South America to central Mexico. It presumably intergrades with *unicolor* in southern Nicaragua; intergradation elsewhere with it seems impossible (see discussion of latter). Intergradation with *orizabensis, rubidus,* and *erebennus* is actually demonstrated, however, by specimens now available (see discussions of each form).

In addition to the data afforded by the 14 specimens examined, ventral and caudal counts of nine others, given by Amaral (*loc. cit.*), have been available. The ventral, caudal, and total counts of these specimens indicate that two subspecies may be involved, although they do not seem separable on the

basis of color characters. One population is represented by specimens from Mexico and Petén, Guatemala, the other by specimens from Costa Rica south. Unfortunately no material is available from the intermediate area. The counts thus segregated are as follows:

	Northern		Southern	
	Males	Females	Males	Females
Ventrals	191–202 [3]	197–202 [4]	203–208 [8]	204–214 [6]
Caudals	71 80 [2]	71–77 [4]	77–88 [8]	73–80 [5]
Total	262–278 [2]	268–279 [4]	280–296 [8]	279–294 [4]

More specimens will be necessary to demonstrate whether these apparent differences are real. In each area there appears to be a general trend toward higher counts to the south, lower counts to the north.

TABLE 3 —SCALE COUNTS IN MELANOCERCUS

Number	Sex	Ventrals	Caudals	Scale rows	Supra-labials	Antepe-nultimate labial	Locality
25093	♂	191	71	17–15	– –	Contact	Veracrus
11636	♂	198	80	17–15	8–8	Contact	Yucatán
6554	♀	197	76 +	17–15	8–8	Contact	Yucatán
46393	♀	200	77	17–15	8–8	Contact	Yucatán
110871	♂	202	71 +	17–15	8–8	Contact	Chiapas
110870	♀	198	71	17–15	8–8	Contact	Tabasco
110872	?	197	77	17–15	8–8	Contact	Petén
110873	♀	202	71	17 14	8–8	Contact	Petén
71371	♀	199	74	17–15	8–8	Contact	Petén
61947	♂	205	83	17–15	8–8	Contact	Costa Rica
53629	♀	209	80	17–15	8–8	Contact	Panamá
8393	♂	203	83	17–15	8 8	Contact	Panamá
54338	?	—	8J	–15	8–8	Contact	Colombia
14025	♀	207	—	17–15	8–8	Contact	Ecuador

The name *Spilotes melanurus* Duméril and Bibron is not available for this subspecies, since it was suppressed by Gray (Cat. Snakes Brit. Mus., 1858, p. 97), who placed in the same genus (*Spilotes*) *Coluber melanurus* Schlegel (1837). Gray recognized *Spilotes melanurus* (Schlegel) and treated Duméril and Bibron's name as a variety ("Var 1") of *Spilotes corais*. The only other name which has been applied to this subspecies (*Geoptyas collaris* Steindachner) is also suppressed as a secondary homonym of *Coluber collaris* Ménétr., 1832 (= *Contia collaris*), since Boulenger (Cat. Snakes Brit. Mus 2: 31. 1894) included Steindachner's name in the synonymy of *Coluber corais* Boie.

Drymarchon corais rubidus subsp. nov.

Holotype.—U.S.N.M. no. 46430, female, from Rosario, Sinaloa, collected by Nelson and Goldman.

Paratypes.—Twenty-one, including U.S.N.M. no. 46588, San Sebastián, Jalisco; no. 24683, Maria Madre Island, Tres Marias Islands; no. 46538, Acapulco, Guerrero; nos 61948-9, Colima; no. 110877, San Diego, near Tehuacán, Puebla; nos. 30425, 110878–84, vicinity of Tehuantepec, Oaxaca; no. 110885, Ixtepec (San Gerónimo), Oaxaca. EHT-HMS no. 5405, Puente de Ixtla, Morelos; no. 5400, Magdalena, Jalisco; nos. 5331, 5406, El Sabino, Michoacán; no. 5591, Huajintlán, Guerrero; and no. 21514, "Guerrero."

Diagnosis.—Dorsal surface, including top of head, uniformly black in

adults; extreme posterior portion of belly and subcaudal surface black, remainder of belly salmon pink, except for lateral black marks, most of labials black-edged posteriorly, the rest of labial area white or pink, sharply differentiated from the black areas Ventrals 190 to 203, caudals 69 to 78, totals 262 to 275. Antepenultimate labial in contact with temporal or postocular or both; scale rows posteriorly usually 15.

Description of holotype.—Head scales normal; supralabials eight, the sixth in contact with temporal, infralabials nine, five in contact with chin shields, four with anterior chin shields; latter a little shorter and wider than posterior chin shields; one preocular; two postoculars; temporals 2-2; ventrals 193; anal entire; tail tip missing. Total length 973 mm, tail 151 mm (incomplete).

Nearly uniform black above, a little lighter posteriorly; sides of head, as well as top, black, to below eye; posterior borders of all supralabials black, remainder of labial area white, sharply differentiated from black borders, scales in posterolateral gular area black-tipped. Ventral surface of tail and extreme posterior portion of belly black; remainder of belly light, with a slight reddish tinge, except for a black mark on the posterolateral edge of almost every ventral.

Variation.—There is little variation in coloration in the twenty paratypes. Larger specimens are quite uniform black above (type a little lighter posteriorly) Specimens in life have a distinctly salmon-colored belly.

TABLE 4 —SCALE COUNTS IN RUBIDUS

Number	Sex	Ventrals	Caudals	Scale rows	Supralabials	Antepenultimate labial
5331	♂	198	76	17 15	8-8	Contact
5400	♂	190	72	17 15	8-8	Contact
5405	♀	201	69 +	17–15	8-8	Contact
5406	?	—	—	—	—	Contact
5591	♀	194	70	17–15	8 -8	Contact
21514	♀	197	—	17–15	8-8	Contact
24083	♂	203	82	17–15	8-8	Contact
30425	♀	194	73	17 15	8–8	Contact
46430	♀	193	.	17–15	8-8	Contact
46538	♂	197	77	17–15	8-8	Contact
46588	♂	191	69 +?	17 -15	8-8	Contact
61948	♂	190	—	17–15	8-8	Contact
61949	?	198	–	17–14	8-8	Contact
110877	♂	196	73	17 15	8-8	Contact
110878	♂	191	72	17–15	8-8	Contact
110879	♂	197	75	17–15	8-8	Contact
110881	♂	192	76	17–15	8-8	Contact
110880	♀	195	67 +	17–15	8 8	Contact
110882	♀	197	74	17 15	8-8	Contact
110885	♂	192	75	17–15	8 8	Contact
110883	♀	195	—	17–14	8-8	Contact
110884	♂	197	78	17–15	8- 8	Contact

In scutellation the series is uniform with the exception of the Tres Marias Island specimen, which, like certain other snakes on the same Islands, differs from its mainland relatives by having a higher number of ventrals and caudals. It is a male, with 203 ventrals and 82 (+?) caudals, the highest mainland counts are 201 ventrals in a female (highest male count 198), and 78 caudals in a male. If further specimens from the islands consistently have high counts, they should be recognizable as belonging to a different subspecies.

Remarks.—The uniformly dark dorsal coloration, white or pink labial areas and high caudal count separate this subspecies from all others.

Seven specimens represent intergrades between *rubidus* and *melanocercus* They are from "Tehuantepec" (no. 61959); El Barrio, Oaxaca (no. 30526); Santa Efigenia, Oaxaca (no. 46496); Tonalá, Chiapas (nos. 110875–6); La Esperanza, Chiapas (no. 110874); and Valley of Comitán, Chiapas (no. 46587). Three of these specimens—those from Tonalá and La Esperanza—are adults, and definitely are intermediate in character between *rubidus* and *melanocercus*

TABLE 5 —SCALE COUNTS IN MELANOCERCUS-RUBIDUS INTERGRADES

Number	Sex	Ventrals	Caudals	Scale rows	Supra-labials	Antepenultimate labial
30526	♀	192	76	17–14	8–8	Contact
46496	♀	196	70	17–15	8–8	Contact
46587	♀	193	—	17–15	8–8	Contact
61959	♂	199	73	17–15	8–8	Contact
110874	♀	202	79	17–15	8–8	Contact
110875	♀	193	73 +	17–15	8–8	Contact
110876	♂	193	71	17–15	8–8	Contact

They are distinctly lighter anteriorly than posteriorly (not so light as in *melanocercus*), the tail is jet black, the labial marks are less numerous than in *rubidus*, restricted to the subocular and postocular labials (as in *melanocercus*); the light areas of the lips are dull brown (not white as in *rubidus*), the posterolateral gular scales have slightly darker tips; and the belly is little marked with black anteriorly (as in *melanocercus*) These characters are definitely intermediate between those of *rubidus* and *melanocercus*, and cannot be construed as indicating intergradation between either one of these and *unicolor*. In fact, that such intergradation does not occur is indicated by the existence of *rubidus-melanocercus* intergrades at La Esperanza with typical *unicolor*.

The other four specimens unfortunately are juveniles, and accordingly cannot definitely be assigned to the category in which they are here placed as *rubidus-melanocercus* intergrades. They are tentatively referred to this category because of an apparent combination in them of the characters of the two forms, and because of geographic probability One of them with indefinite locality ("Tehuantepec") has the tail little darker than the rest of the body, and distinctly mottled and banded, the whole body is a little lighter than in the others. This may be a juvenile *unicolor*, although the distinct lateral black marks on the belly do not so indicate. It furthermore may represent an intergrade between *unicolor* and *rubidus* (*rubidus-melanocercus*), but in view of other evidence that such intergradation does not occur, it is not well to draw conclusions upon the basis of this juvenile in which adult features are not evidenced.

The other three specimens appear to be typical intergrades (as characterized by the adults), with the exception that about half the ventrals have a black lateral streak, as typical of adult *rubidus*. The same marks, however, are indicated in the adult *rubidus-melanocercus* intergrades, although poorly defined. Presumably sharp definition of them is a juvenile characteristic in the intergrades; in typical *rubidus* they are sharply defined in the largest adults as well.

Drymarchon corais orizabensis (Dugès)

Morenoa orizabensis Dugès, Proc. Zool. Soc. London, 1905: 517–518, fig. 77.

Type locality.—Orizaba, Veracruz.

Diagnosis.—Adults entirely black above; most of sides of head black; anterior portion of belly heavily pigmented, less than half anterior third light; remainder of ventral surface black; light areas on belly white or cream, not pink; ventrals 186 to 201, caudals 71 to 78. Antepenultimate labial in contact with temporal or postocular or both (rarely not); scale rows rarely reduced to 14 in front of anus.

Range.—Atlantic slopes from near the Isthmus of Tehuantepec about to Mirador, Veracruz. Perhaps restricted to the foothills.

Specimens examined.—Five typical specimens were examined: the type, in the museum at Guanajuato, Mexico; U S.N.M. no. 110886 and EHT-HMS nos. 5368, 5592–3, all from Potrero Viejo, Veracruz, and U.S.N.M. no. 24999, Mirador, Veracruz.

Remarks —The type is a juvenile; its association with the very black adults from the same area is prompted for geographic reasons. The form is most nearly like *rubidus*, from which it differs in having the belly almost entirely black (much as in *couperi*), and the light ventral areas not red but white or cream Its similarity to *rubidus* does not necessarily mean that it is more closely related to that form than to any other. There is evidence that the two are of independent origin.

TABLE 6 —SCALE COUNTS IN ORIZABENSIS

Number	Sex	Ventrals	Caudals	Scale rows	Supra-labials	Antepenultimate labial
5368	♀	201	71	17–15	8–8	Contact
5592	♂	192	64+	17–15	8–8	Contact
5593	♂	186	71	17–15	8–8	Contact
24999	?	195	—	—	8–8	Contact
110886	♂	193	76	17–15	8–8	Contact
Type	♂	199	78	17–15	7–8	Contact

Intergradation between *melanocercus* and *orizabensis* is demonstrated by a series of four specimens bearing the locality data Mirador, Veracruz (nos. 25000–3). Two of these are adults; they have the head and the anterior half of the body peculiarly mottled with jet black on a brown ground color; the posterior third of the dorsum is entirely jet black, the tail black above and below; most of the labials are black-edged. This condition is certainly intermediate between that of *melanocercus* and *orizabensis* The two young are similar, except that light bands are evident on the anterior portion of the body; the bands are broad, covering about two scale lengths, as in *melanocercus*.

It is to be noted that both typical *orizabensis* and typical *melanocercus* occur near this locality, if the data on two specimens, presumably from the environs of Mirador, can be trusted (no 25093, *melanocercus;* no. 24999, *orizabensis*). Both these specimens are unquestionably identifiable, even though one (*melanocercus*) is a juvenile.

Upon the evidence of these data, and also because an intergrade of *melanocercus* and *erebennus* is available from farther north, it appears reasonable to assume that *melanocercus* is typically a plains species, while *orizabensis* must be restricted to the extensive area of forested foothills in central and

southern Veracruz, from which all specimens with positively known locality data have been taken.

TABLE 7 —SCALE COUNTS IN ORIZABENSIS-MELANOCERCUS INTERGRADES

Number	Sex	Ventrals	Caudals	Scale rows	Supra-labials	Antepenultimate labial
25000	♀	199	—	17–15	8–8	Contact
25001	♂	196	74	17–15	8–8	Contact
25002	♂	190	72	17-15	8–8	Contact
25003	♀	191	72	17–15	8–8	Contact

Drymarchon corais erebennus (Cope)

Georgia obsoleta Baird and Girard, Cat. N Amer. Rept , pp. 158–159. 1853.
Spilotes erebennus Cope, Proc Acad. Nat. Sci. Philadelphia, 1860· 342 (substitute name for *Georgia obsoleta* Baird and Girard); *idem*, p. 564.
Coluber corais Boulenger (part), Cat Snakes Brit. Mus. 2: 31, 1894. (suppresses *Coluber obsoleta* [Baird and Girard], as a homonym of *Coluber obsoletus* Say, making available *erebennus* Cope)

Type locality.—Eagle Pass, Texas.
Diagnosis.—Black above posteriorly, becoming spotted or banded on middle

TABLE 8 —SCALE COUNTS IN EREBENNUS

Number	Sex	Ventrals	Caudals	Scale rows	Supra-labials	Antepenultimate labial
A656	♂	189	63 +?	17–14	8- 8	Contact
1843	♂	189	61	17–14	8–8	Contact
1859	♂	184	59	17–14	8–8	Contact
1862	♂	—	55	17–14	8–8	Contact
1860	♂	186	56 +?	17–14	8–8	Contact
15675	♀	186	60	17–14	8–8	Contact
15872	♀	191	65 +	17–15	8–8	Contact
16142	♂	183	—	17–15	8–8	Contact
25200	♂	186	65	17–15	8–8	Contact
26439	♀	193	57	17–14	8–8	Contact
32783	♂	183	—	17–14	8–8	Contact
37515	♂	188	59	17–14	8–8	Contact
65165	♂	186	55	17–14	8–8	1 side
82564	♂	188	—	17–14	8–8	1 side
105307	♂	186	—	17–14	8–8	Contact
105308	♂	183	—	17–14	8–8	Contact
110866	♀	192	—	17–15	8–8	Contact
110867	♂	192	—	17–14	8–8	Contact
110868	♀	188	62	17–14	8–8	Contact
110869	♂	187	58	17 -14	8-8	Contact

and anterior part of body in adults; subcaudals less than 68 (55 to 65); antepenultimate labial in contact with temporal or postocular or both; scale rows near anus usually 14.

Range.—Central southern Texas south to extreme northern Veracruz and central Hidalgo.[3]

[3] The specimen from Tasquillo, Hidalgo, described by Martín del Campo (Anal. Inst Biol. Mex 8: 264–265 1937) is obviously of this subspecies Apparently the form extends up the valleys of the Panuco river system, to which the Río Tula that flows by Tasquillo belongs On maps the spot appears well within the plateau of Mexico.

Specimens examined.—Twenty, from the following localities: HIDALGO: Km. 332, 5 kilometers south of Chapulhuacán (no 110868). VERACRUZ: Tuxpán (no. 25200). SAN LUIS POTOSÍ: Huichihuayán (no. 110869). TAMAULIPAS: Hda. La Clementina, 4 miles west of Forlón (nos. 105307–8, 110866–7; EHT-HMS no. 15872); Matamoras (no. 1859). COAHUILA. Sabinas (no. 37515). TEXAS: Brownsville (nos. 1860, 32783); Lower Rio Grande (no 1843); San Diego (no. 15675); Eagle Pass (no. 1862, type), Cameron County (no. 65165); McAllen (no. 82564), Las Moras Springs, Kinney County (no. 26439); 29 miles north of Brownsville (Kans. Univ. no. 16142); no locality (EHT no. A656).

Remarks.—This subspecies is well differentiated from all others, having a unique character in usually possessing 14 scale rows near the anus; it differs from all others except *couperi* in having less than 68 caudals

An intergrade between this subspecies and *melanocercus* is represented by No. 46447 from Metlatoyuca, Puebla (extreme northeastern corner) The coloration of the specimen is exactly typical of *melanocercus*, but the scutellation is that of *erebennus:* scale rows 17-14; ventrals 186; caudals 63, supralabials 8–8; antepenultimate labial in contact with temporal, female

TABLE 9 —SCALE COUNTS IN COUPERI

Number	Sex	Ventrals	Caudals	Scale rows	Supra-labials	Antepenultimate labial
4457	♂	185	66	17–15	7–8	Separated
4458	?	---	—	—	7–8	Separated
4504	♀	186	63	17–15	8–8	Separated
10379	♂	186	67	17 15	8–8	Soparated
10465	♀	195	64	17–15	8–8	Separated
10790	♂	188	65	17–15	8–8	Separated
10824	♀	193	64	17–15	8–8	Separated
14842	♂	187	66	17–15	7 8	Separated
18514	♂	187	64	17–15	8–8	Separated
24605	♂	187	65	17–15	8–8	Separated
26618	♂	187	65	17–15	8–8	Soparated
36481	♂	186	67	17–15	8–8	Separated
37354	?	—	—	—	8–8	Separated
38101	♂	185	67	17–15	7–8	Separated
38153	?	—	—	—	7–8	Separated
38367	♀	193	63	17–15	8–8	Separated
38579	♂	189	—	17–15	7–7	Separated
38683	♂	187	---	17–15	8–8	Separated
44187	♂	187	—	17–15	7–8	Separated
44519	?	—	—	—	7–7	Separated
61218	♂	186	—	17–15	8–8	Separated
83317	♂	187	67	17–15	8–8	Separated
85307	♂	187	—	17–15	8–8	Separated
85308	♂	189	64	17–15	8 8	Separated
85309	♂	185	66	17–15	8–8	Separated

In color, the subspecies perhaps most easily confused with *erebennus* is *rubidus;* the latter, however, has the back uniform black in adults, and is not spotted anteriorly on dorsal surface; also, the light areas on the lips are white or pink, sharply differentiated from the black (brown in *erebennus*).

Drymarchon corais couperi (Holbrook)

Coluber couperi Holbrook, N. Amer. Herp , ed. 2, 3 : 75, pl. 16. 1842.
Drymarchon corais couperi Stejneger and Barbour, Check List N. Amer. Amph. Rept., ed. 2, p. 93. 1923.

Type locality.—Dry pine hills south of Alatamaha, Ga.

Diagnosis.—Adults uniform black above and below, except gular region; caudals less than 68; antepenultimate labial separated from temporal or postocular by contact above it of adjacent labials; 15 scale rows in front of anus.

Range.—South Carolina to Florida, westward to southern Louisiana (Stejneger and Barbour)

Specimens examined.—Twenty-five. FLORIDA: Silver Springs (Kans. Univ. no. 18514); Lemon City (no. 38153); Kissimee River (no. 36481); West Palm Beach (no. 37354); Gainesville (nos 10465, 10790, 10824, 14842); Orlando (nos. 26618, 83317); Norwalk ? (nos. 38367, 38683); Clearwater (no. 10379); Pinecrest (nos 85307–8); Canaveral (no. 44519); Miami (no. 85309); "Florida" (nos. 44187, 24605, 38101, 38579, 61218). GEORGIA: Brunswick (no. 4504); Liberty County (nos. 4457–8).

Remarks.—The existence of a hiatus between the ranges of *couperi* and *erebennus* makes questionable the status of these two as subspecies of the same form. The eastern subspecies, however, is so obviously a derivative of *erebennus*, and their characters in general are so similar, that their relationship is probably best expressed as the name has been used in the past.

This subspecies is the most highly modified of the whole genus It has a completely evolved, terminal type of color pattern (all black, shared with *orizabensis*), insofar as the trend toward complete melanism is concerned. In addition it possesses three modifications in scutellation, while only one or two modifications occur in other members of the genus: (1) Reduced caudals (shared with *erebennus*); (2) antepenultimate labial separated from temporals and postoculars (unique, almost invariable); and (3) reduction of supralabials to 7 (unique, but in only 20 percent of the counts). Of course, there are changes observable in ventral counts in the various forms of the genus, but the trend in general is so gradual from north to south or vice versa that no one form can be credited with the development of a unique amount or type of variation in this character.

CONCLUSIONS

A number of problems made evident but not solved by the present study may be listed:

1. The existence of other forms, particularly of types more melanistic than *corais*, is to be looked for in South America.

2. The question of intergradation between *corais* and *melanocercus* in South America is still open. Theoretically there should be no intergradation between them, although Amaral (*op. cit.* p. 328) states that "Certain examples from Colombia appear intermediate between *corais corais* and *corais melanurus.*"

3. The exact ranges of *melanocercus* and *unicolor*, and the areas of intergradation between them, are yet to be determined.

4. The apparent lack of intergradation, and overlapping of ranges, of *unicolor* and presumed intergrades between *melanocercus* and *rubidus* in southern Chiapas, need verification.

5. There is some evidence that the presumed intergrades between

rubidus and *melanocercus* may be recognizable as a different subspecies, even though its characters undoubtedly have arisen through hybridization between these two forms. Suggestive of this are two specimens from Achotal, Veracruz, in Field Museum of Natural History: one is typical *melanocercus*, the other a typical *melanocercus-rubidus* intergrade; both are adults.

6. The possible split of *melanocercus* into two subspecies should be settled by examination of Honduras and Nicaragua specimens; it is barely possible that *unicolor* extends completely across Nicaragua, in which case an actual separation of a northern and southern population of *melanocercus* is evident.

7. The exact range of *orizabensis* is yet to be defined.

8. The apparent existence of *melanocercus* on the plains of Veracruz north of the Isthmus, indicated by several intergrades between that form and *orizabensis* and *erebennus*, should be verified.

9. The apparent hiatus between the ranges of *erebennus* and *couperi* should be investigated. If these two forms are proved to be separated from each other geographically, their rather sharply different morphological and pattern characters suggest the possibility of considering *couperi* a distinct species.

ZOOLOGY.—*A new brittle-star of the genus* Ophiocomella *from Canton Island.*[1]   AUSTIN H. CLARK, U. S. National Museum.

The genus *Ophiocomella* was diagnosed in 1939 with the type species *O. caribbaea*, a small 6-armed form that previously had been considered as the young of *Ophiocoma pumila*. The species assigned to the genus were *Ophiocomella caribbaea*, sp. nov., *O. parva* (H. L. Clark), *O. schmitti*, sp. nov., and *O. clippertoni*, sp. nov. (the last a tentative name for specimens from Clipperton Island doubtfully referred to *O. parva*). The discovery of another species of this curious genus is a matter of considerable interest.

Ophiocomella schultzi, sp nov

Description.—The disk is circular, not notched at the arm bases, slightly elevated, 4.3 mm in diameter; the six rather slender arms are 17 mm long; the arms are separated by about three times their basal width. The specimen is sexually mature.

The aboral surface of the disk is covered with fine, overlapping, conspicuously punctate scales. About one-quarter of these scales bear short roughened cylindrical spinelets, which are about twice as high as thick with low-conical or rounded tips. These are rather widely spaced, being usually two to four

times their width apart. There are 50 to 60 of these to each square millimeter. The radial shields are visible as small rounded plates between two and three times as long (radially) as broad situated at the edge of the disk, one on each side of the arm base. The edge of the disk is sharp. On the oral side the interradial areas are covered with fine imbricating scales resembling those on the aboral surface but without spinules, these not extending beyond the sharpened edge of the aboral surface where they stop abruptly.

The upper arm plates are fan-shaped, in the earlier portion of the arm about as long as broad. The distal border is approximately hemispherical, somewhat flattened centrally, passing over into the straight lateral edges which converge at an angle of 90°. The proximal angle is rather broadly truncated by the overlapping of the preceding upper arm plate. In the distal portion of the arms the side arm plates encroach more and more on the dorsal surface and finally meet so that in the terminal portion of the arm the upper arm plates, here much reduced in size, are separated by the broad middorsal union of the side arm plates for as much as their own length. The terminal portion of the arm becomes more or less moniliform.

The first side arm plate beyond the edge of the disk has four arm spines, the second five, and those following four, the number falling to three near the arm tip. The uppermost arm spine is about as long as two arm segments, slender, tapering, somewhat flattened, and usually more or less swollen basally and slightly bent distally. On the second arm comb beyond the disk a similar but slightly smaller spine is inserted above the spine corresponding to the uppermost spine on the other plates. The second spine is slightly more slender and slightly shorter than the uppermost. The third spine is about two-thirds the length of the second, tapers somewhat more rapidly, and is slightly curved downward. The lowest spine is slightly more slender than the third and shorter, about the length of an arm segment.

The under arm plates are at first about as long as broad, after about the sixth becoming longer than broad They are very slightly broader distally than proximally with very broadly rounded distal angles, similarly rounded proximal angles, and slightly concave sides.

The first tentacle pore has two tentacle scales, those following a single rather broad distally pointed scale situated on the side arm plate.

The oral shields are longer than broad, the outer portion approximately hemispherical, the lateral edges converging to a broadly rounded proximal end.

The adoral plates are triangular, the slender produced inner apices extending downward along the sides of the oral shields so as almost or quite to meet the apex of the other of the same pair.

The mouth papillae are four or five in number, well rounded, decreasing in size and in relative width toward the apex of the jaws.

The color of the disk is pale greenish gray with a few rather large indefinite spots of yellow brown; the arms are whitish with occasional indistinct yellow brown blotches.

Locality —Canton Island, lagoon; collected by Dr. Leonard P. Schultz on April 28, 1939 (U.S.N.M. no. E.5919, type).

Remarks.—This new species is related to *O. schmitti* from which, however, it is quite distinct. The spinules on the disk are finer, more numerous, and much shorter; the upper arm plates are broader and more rounded with the lateral edges making a greater angle with each other; the second side arm plate beyond the disk carries an extra spine aborally; and the oral shields are broader and more rounded.

It seems to differ from *O. parva* (H. L. Clark) from Torres Strait in having the radial shields visible and the granules on the disk more elongated, and in having an extra arm spine on the second side arm plate beyond the disk. In the original description *O. parva* is said to have a single tentacle scale, but the figure shows two on at least two of the first tentacle pores.

Obituaries

MORTON GITHENS LLOYD, distinguished engineer and chief of the Safety Codes Section at the National Bureau of Standards since 1917, died April 26, 1941, at his home in Chevy Chase, Md., after a short illness. Born September 10, 1874, in Beverly, N. J., Dr. Lloyd was educated at the Central Manual Training High School, Philadelphia, and at the University of Pennsylvania, recieving a bachelor of science degree there in 1896, a Ph.D. in 1900 and the E.E. degree in 1908. He also had studied at Harvard University and the Friedrich Wilhelms Universitat, Berlin. Dr. Lloyd was an instructor in physics at the University of Pennsylvania from 1899 to 1902. From the latter year to 1910 he had served as laboratory assistant, assistant physicist, and associate physicist at the Bureau of Standards. He was technical editor of the Electrical Review and Western Electrician, from 1910 to 1916

During his professional career Dr. Lloyd made special investigations of the effects of self induction and capacity in alternating-current circuits; thermomagnetic and galvanomagnetic effects in bismuth and tellurium; effects of wave form upon induction meters, core loss and ratio of transformers and hysteresis, effects of phases of harmonics upon quality of sound; measurement of hysteresis and eddy currents; magnetic hysteresis in rotary field; regulation of public utilities, accident prevention; and lightning.

Dr. Lloyd took a prominent part in many national associations He was a fellow of the American Institute of Electrical Engineers, a member of the Washington Academy of Sciences, the American Association of Engineers, United States National Committee of the International Commission of Illumination, president of the International Association of Electrical Inspectors, member of Franklin Institute, Federal Interdepartmental Safety Council, Federal Accident Statisticians, American Association for Labor Legislation, Philosophical Society of Washington, National Fire Protection Association, National Safety Council, past president of the American Society of Safety Engineers, Safety Code Correlating Committee of the American Standards Association, and was an honorary member of the International Municipal Signal Association. He was also a member of the International Electrical Congress, St. Louis, 1904, and Turin, 1911; the International Engineering Congress, San Francisco, 1915, and the International Congress on Illumination, Saranac, N. Y., 1928.

He was elected a member of the honor research fraternity, Sigma Xi. He received a medal from the Louisiana Purchase Exposition, 1904, and was the recipient of the Edward Longstreth Medal of the Franklin Institute, 1910. Dr. Lloyd was the author of numerous technical articles. His writings have been published in bulletins of the Bureau of Standards, Electrical Review and Western Electrician, Electrical World, Proceedings of the A.I.E.E., Proceedings of the International Association of Municipal Elec-

tricians, Journal of the Franklin Institute, Safety Engineering, and Proceedings of the International Association of Electrical Inspectors.

Dr. Lloyd belonged to All Souls Unitarian Church and was a past president of the community association of section three, Chevy Chase, Md. On June 20, 1907, Dr. Lloyd married Miss Ethel Tucker Maurer of Washington, D. C. He is survived by his widow, a daughter, and a son.

WILLIAM LASH MILLER, C.B.E., professor emeritus at the University of Toronto, died on September 1, 1940. He was born at Galt, Ontario, Canada, on September 10, 1866. He attended the University of Toronto, where he was granted an A.B. degree in 1887. He subsequently studied at the Universities of Berlin, Göttingen, Munich, and Leipzig, and obtained the degree of doctor of philosophy from the University of Munich in 1890. Professor Miller was a member of the staff of the University of Toronto for 48 years. After having served as fellow and demonstrator, he was appointed associate professor of physical chemistry in 1900, professor in 1908, head of the department of chemistry in 1921, and was retired as professor emeritus in 1937. In 1935 he was made a Commander of the Order of the British Empire.

Professor Miller made many important contributions to chemical thermodynamics, especially in the field of electrochemistry. He was author of more than 100 original publications, including several comprehensive mathematical papers relating to the kinetics of surface reactions, diffusion, colloidal behavior, and electrochemical phenomena. His review of the *Method of Willard Gibbs in chemical thermodynamics*, published in Chemical Reviews for 1925, exemplifies his most obvious desire to serve his fellow chemists by bringing to their attention the wealth of information to be derived by application of the thermodynamic method. His contributions were not restricted to physicochemical and mathematical investigations, but included fundamental discoveries in other fields, among which may be mentioned the isolation of inositol from Wilder's bios, and the demonstration that inositol is a growth factor for yeasts.

Professor Miller's outstanding ability and wide interest in the development of science brought him many honors and responsibilities in scientific organizations. He served the Journal of Physical Chemistry as member of the board of reviewers from 1896 to 1910 and as associate editor from 1910 to 1926. He was chairman of the chemistry section of the Association for the Advancement of Science in 1913 and in 1923. An honorary member of the American Chemical Society, he served as chairman of the section of physical chemistry in 1906 and as associate editor of the Journal of the American Chemical Society from 1913 to 1924. Professor Miller was one of the founders of the Canadian section of the Society of Chemical Industry and served as chairman in 1910. He was an honorary member of the Electrochemical Society and was elected president in 1912. He was also a member of Franklin Institute, an honorary member of the Electroplaters Association, Fellow of the Royal Society of Canada, serving as president in 1935, a member of the Canadian Institute of Chemistry, serving as president in 1926, and a member of the British Association for the Advancement of Science which he served as vice-president in 1924. He was elected to membership in the Washington Academy of Sciences in October, 1903.

MATHEMATICS —*Intuitive and descriptive geometry of function space Tensors and bi-vectors* [1]　BRUCE LONGTIN, Department of Chemistry, Illinois Institute of Technology, and MERLE RANDALL, Department of Chemistry, University of California (Communicated by FREDERICK D ROSSINI)

In the preceding papers[2][3] a graphical method of representing the geometry of function space was developed The method depended principally upon a vector geometry The present paper briefly discusses the geometrical representation of more complex multiple numbers

BI-VECTORS

The representation of an ordinary *real vector* was made by subdividing an interval Δ into n equal parts, in the center of each interval an ordinate was erected equal to the magnitude of one of the n components When any component is a complex number $(u_j + iv_j)$, it is represented by an Argand diagram rather than by a single coordinate Hence, a bi-vector, $u + iv$, is to be represented by erecting the Argand diagram for each component at the center of one of the subintervals of Δ

In Fig 1 the bi-vector $(2 + i3, 1 - i, i, 2)$ is shown The four Argand diagrams are arranged along the axis of indices with their real axes vertical and their imaginary vertices horizontal The real and imaginary axes could have been interchanged The particular choice was made in order that the diagram may reduce directly to the simple real vector diagram when the imaginary components vanish As in the simple case, the four points representing the four components are joined by a single broken line to indicate that they belong to the same bi-vector

In the case of an infinite number of dimensions, the components $(u_j + iv_j)$ become in the limit values of the complex function, $\phi(x) = u(x) + iv(x)$ If the functions $u(x)$ and $v(x)$ are continuous, the con-

necting broken line of Fig. 1 becomes the continuous space curve of Fig. 2. The Argand vectors representing the individual components of ϕ then generate a *helicoidal* surface terminated by the X axis and this space curve. If the functions $u(x)$ and $v(x)$ are not continuous, the space curve may be extremely discontinuous, consisting only of a scattering of points.
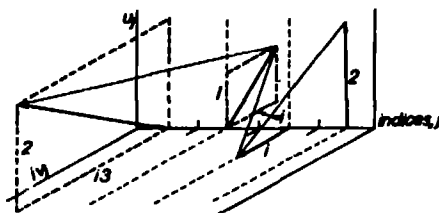
Fig. 1 —A 4-component bi-vector in the proposed representation
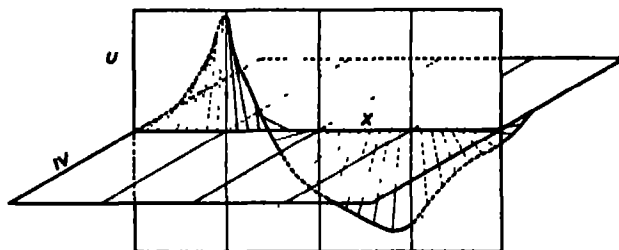
Fig 2 —An *n*-component bi-vector in function space.

With the use of this representation of a bi-vector, all the graphical results obtained for real vectors may be repeated. It is necessary only to give due consideration to the presence of the imaginary terms. For example, the sum of two bi-vectors, $\phi + \psi$, is a bi-vector, represented by the function $(\phi(x) + \psi(x) = (u_\phi(x) + u_\psi(x)) + i(v_\phi(x) + v_\psi(x)))$. This function is obtained graphically by adding the Argand vector of $\psi(x)$ to that of $\phi(x)$ vectorially for each value of x. This single example is sufficient to indicate the general plan of development.

AN ALTERNATIVE METHOD OF REPRESENTING BI-VECTORS

The Argand diagram by which the bi-vector, $(u + iv)$, was represented in Figs. 1 and 2 might equally well be represented by plotting u-components as in the upper part of Fig. 3 and the v-components in the lower part of the diagram. It is to be understood that the lines for the u- and v-components erected at the center of the several subintervals of Δ must be considered as tied together by the restriction that they are to be considered as being projections corresponding to the plane of Fig. 1 at a given index j.

Thus, while all the propositions that we have given for real vectors may be repeated for either the real component (upper half of Fig. 3) or the imaginary component (lower half of Fig. 3) the arrangement of coordinates chosen for the real component must be rigidly adherred to for the imaginary component. We thus simultaneously apply all the theorems previously developed but apply the restriction that any particular arrangement of groups chosen for the one component must also be used for the second or imaginary component of the figure.
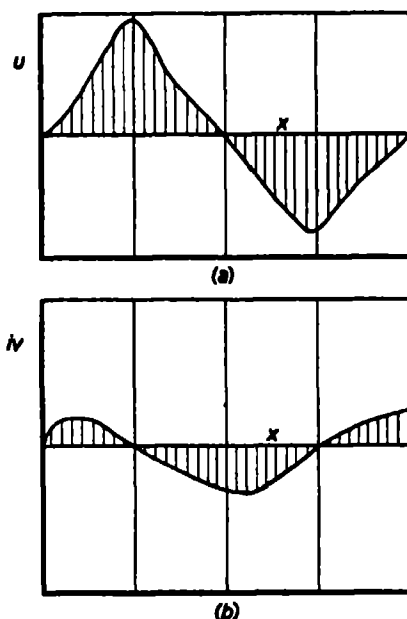
Fig 3 —Alternative method of representing bi-vectors (a) Real part; (b) imaginary part of Argand diagram.

REPRESENTATION OF PHASE SPACE FOR n PARTICLES

In statistical mechanics, the concept of a phase space composed of three positional and three momentum coordinates for each of n particles has proved useful. The coordinates of such a phase space may be represented graphically by a method closely analogous to that used in representing bi-vectors.

The phase coordinates to be represented are three position coordinates, $q_1(x)$, $q_2(x)$, $q_3(x)$, and three momentum coordinates, $p_1(x)$, $p_2(x)$, $p_3(x)$, of the x^{th} particle, for n such particles. The coordinates of each particle constitute the components of a 6-dimensional vector. In 7-dimensional space, one might subdivide the X-axis into small intervals, each assigned to a particular particle. At the center of each

interval, one would then erect the 6-dimensional vector which represents the phase coordinates of that particular particle.

In practice, it is necessary to use projections of the 7-dimensional figure. It is sufficient to use three solid diagrams, each corresponding to one of the three dimensions of physical space. Each diagram would be similar to Fig. 1 (or to Fig. 2 if the number of particles is infinite). In the first, the coordinates $q_1(x)$ and $p_1(x)$ would replace the real and imaginary parts, respectively, of the bi-vector. The second and third would represent, respectively, the pair of components $q_2(x)$, $p_2(x)$, and the pair $q_3(x)$, $p_3(x)$.
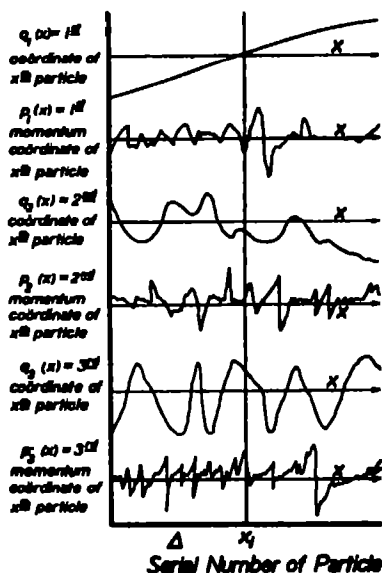
Fig 4 —A 6n diagram showing the coordinates and phase components of a highly improbable state of a system of n particles.

It is, of course, more convenient to use six plane views of the 7-dimensional figure, as is done in Fig. 4. In each view, one of the coordinates $q_1(x)$, $q_2(x)$, $q_3(x)$, $p_1(x)$, $p_2(x)$ and $p_3(x)$, is plotted against the variable x, which labels the particular particle to which the coordinate belongs.

It is like a 3-dimensional Argand diagram that uses a 2-dimensional vector for each component of the bi-vector. But here we need a 6-dimensional *vector* for each particle. Each 6-dimensional vector might be considered as one sextuple component of a sextuple vector in n-space, as compared to the n double components of a bi-vector. By a sextuple vector, we mean one having six sets of components, just as a bi-vector has two sets of components (real and imaginary).

Concerning the appearance of the phase space diagram, we can not presume that the physical system has at the present instant a distribution of coordinates and moments that corresponds to the statistically most probable distribution. Actually it may never have this distribution.

Any set of six curves that we might draw represents a possible configuration of the system. The more regular curves represent quite improbable configurations, with unusually high total energy, but nevertheless possible configurations. The regularity of the curves necessarily implies an orderly arrangement of the particles in space along some smooth space-curve and some regularity in the distribution of momenta.

On the other hand, if the momenta showed Maxwell-Boltzmann distribution, each would follow a curve $q_i(x) = (\ln x)^{1/2}/x$, if arranged monotonically. However, only one of the components at a time could be so arranged. The rest would be randomly permuted arrangements of the same function. Similarly, each of the coordinates, $q_i(x)$, would be represented by a randomly permuted form of the function $q_i(x) = b + cx$, in the absence of any special forces which favor other than random spatial distributions of particles. A fuller discussion will be given later.

TENSORS

A tensor of second rank in terms of the base vectors[4] e_i^0 is

$$\mathbf{A}_{(2)} = \sum_{i,j} A^{ij} e_i^0 e_j^0. \tag{1}$$

Furthermore, it is invariant to a change in the base vector system. Hence it must be expressed in terms of the reduced base vector system as[5]

$$\mathbf{A}_{(2)} = \sum_{i,j} A'^{ij} e_i' e_j', \tag{2}$$

where

$$A'^{ij} = A^{ij}/(\Delta/n). \tag{3}$$

A tensor is sometimes represented graphically by the invariant quadric surface, $\mathbf{v} \, \mathbf{A}_{(2)} \, \mathbf{v} = 1$, associated with it. This representation may be extended to n dimensions, and is useful in visualizing the concept of the *eigenvectors* of a tensor. However, a more generally useful representation may be obtained by considering the matrix, (A'^{ij}), of the tensor $\mathbf{A}_{(2)}$.

[4] i and j are here used merely as indices, not as $(-1)^{1/2}$
[5] Cf KOWALEWSKI, G. *Ueber Funktionenräume*, Sitz Akad. Wiss. Wien **120** (2a:1): 77. 1911.

The matrix is customarily represented by subdividing a large square into n^2 equal small squares, in each of which an appropriate component, A'^{ij}, of the tensor is entered. The component A'^{ij} is entered in the i^{th} row and j^{th} column of the large square. Fig. 5 is the representation of a matrix associated with a 4-dimensional space. If we

Fig 5.—Matrix of 2-rank and 4-order

imagine that each of the small squares has associated with it the appropriate base vector dyad $e_i'e_j'$, then Fig. 5 is a representation of the tensor.
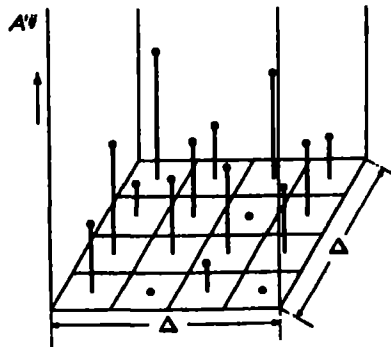
Fig. 6.—The proposed representation of the matrix of Fig. 5

In analogy to the representation of a vector, the matrix representation may be made completely geometric. In Fig. 6 an ordinate has been erected at the center of each of the squares of Fig. 5. The ordinate erected in any particular square is numerically equal to the value A'^{ij} associated with that square in Fig. 5. In order to tie together all the points in the diagram of a single tensor, we may construct a tightly stretched surface (e.g., the surface of least area) between these

points. This surface corresponds to the broken line used in the representation of a vector.

As the number, n, of dimensions of the space is increased, the square of constant dimensions $\Delta \times \Delta$ is subdivided into smaller and smaller squares of dimensions $(\Delta/n) \times (\Delta/n)$. In the limit the component A'^{ij} is found in a square whose center has the coordinates $(a + i\Delta/n)$ and $(b + j\Delta/n)$, respectively. The infinite matrix (A'^{ij}) is, in the limit, represented by a function $A(x, y)$, in which x and y are the limits of $(a + i\Delta/n)$ and $(b + j\Delta/n)$ and are defined only in the intervals $(a, a + \Delta)$ and $(b, b + \Delta)$, respectively. The function $A(x, y)$ may be continuous or so discontinuous that it is represented graphically by a scattering of points rather than a continuous surface.
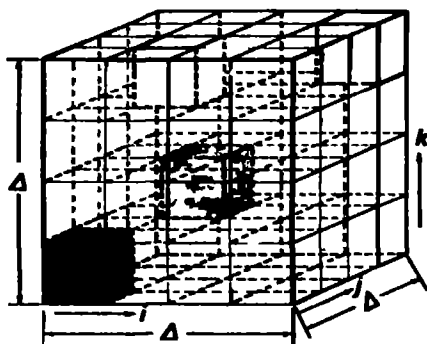
Fig 7 —Representation of a matrix of 3-rank and 4-order

A tensor, $A_{(3)}$, of third rank is an invariant linear form in the base vector triads $e_i^\circ e_j^\circ e_k^\circ$. Its matrix is of the form (A^{ijk}). Expressed in terms of the reduced base vector system its matrix is (A'^{ijk}), where A'^{ijk} is equal to $A^{ijk}(\Delta/n)^{-3/2}$. The matrix may be represented by dividing a cube into n^3 small equal cubes. Each number A'^{ijk} is then inscribed at the center of the appropriate cube (the i^{th} cube in the j^{th} row of the k^{th} layer). The representation becomes more graphic if each small cube is considered to have a mass density equal to the appropriate value of A'^{ijk}. Such a representation is shown in Fig. 7.

In the limit, as n increases, the matrix (A'^{ijk}) is represented by a function $A(x,y,z)$, which is the density at a point (x,y,z) within the cube. If each elementary cube in the mass distribution is considered to have a base vector triad $e_i' e_j' e_k'$ associated with it, then the mass distribution within the large cube represents the tensor $A_{(3)}$. The concept that $A_{(3)}$ is represented by a function $A(x,y,z)$ is readily generalized to tensors of higher rank,[4] but the geometrical picture can not easily be carried further.

TENSOR ADDITION

The sum of two tensors of the same rank is defined as a tensor,

$$C_{(2)} = A_{(2)} + B_{(2)};$$
$$C^{ij} = A^{ij} + B^{ij}.$$

(4)
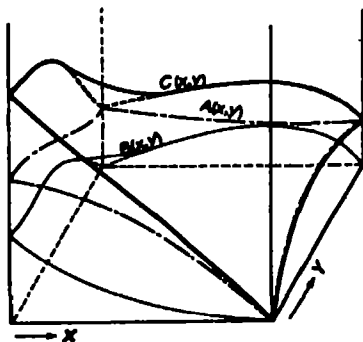
Fig. 8 —Graphical addition of tensors of 2-rank, $\propto$ -order.

In the limit the tensor $C_{(2)}$ is therefore represented by a function,

$$C(x, y) = A(x, y) + B(x, y).$$

(5)

If the tensors $A_{(2)}$ and $B_{(2)}$ are represented by two continuous surfaces, then their sum, $C_{(2)}$, is represented by a continuous surface whose ordinates are sums of the corresponding ordinates of the surfaces representing $A_{(2)}$ and $B_{(2)}$.

VECTOR–TENSOR DOT PRODUCT

The dot product $A_{(2)}$ $\mathbf{v}$ is defined in terms of the reduced base vector system as the vector

$$\mathbf{u} = A_{(2)} \ \mathbf{v} = \sum_{i,j} A'^{ij} \mathbf{e}_i'\mathbf{e}_j' \ \mathbf{v} = \left[\sum_j A'^{ij} v_j(\Delta/n) \right] \mathbf{e}_i$$

(6)

In the limit of a function space, this becomes

$$\mathbf{u} = A_{(2)} \ \mathbf{v} = \sum_j \left[\int_\Delta A(x, y)v(y)dy \right] \mathbf{e}_x.$$

(7)

The transformed vector is represented in the function-space diagram by the function

$$u(x) = \int_\Delta A(x, y) \ v(y)dy.$$

(8)

In Fig. 9 the graphical construction is shown by which the transformed vector may be obtained. For each value of x the tensor traces out a plane curve $A(x_1,y)$. The ordinates of this curve are each multiplied[6] by the corresponding ordinate of the curve $v(y)$ and the area under the resulting curve is taken as the x_1 component of the curve $u(x)$.
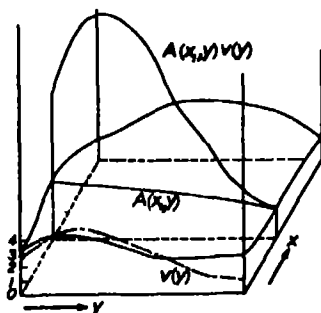
Fig. 9 —A graphical construction for obtaining the dot product
of a ∞-vector and a tensor of 2-rank, ∞-order

An example of the use of a product of the form $A_{(x)}$ **v** is to be found in the calculation of the vapor pressure of a petroleum fraction from its true boiling point assay. The vapor pressure of a pure hydrocarbon is a function of the temperature T, and of the true boiling point θ (i.e., is different for each hydrocarbon and is correlated with the true boiling point of the hydrocarbon). It may be expressed as $P(T,\theta)$. Suppose the mol fraction of hydrocarbons whose true boiling points lie in the range $(\theta, \theta+d\theta)$ is $x(\theta)d\theta$ in a particular mixture. Then Raoult's law gives $x(\theta)P(T, \theta)d\theta$ as the vapor pressure of this particular group of hydrocarbons. The total vapor pressure of the mixture is $\int x(\theta)P(T,\theta)d\theta$. Hence the total vapor pressure may be expressed as the vector tensor product, **P** **x**, and is a function of the temperature at which it is measured.

Function-space tensor operations in the form of equation 8, have been studied extensively. Equation 8 defines the Fredholm transformation of $v(y)$, which forms the basis of the Fredholm theory of integral equations.[7] Having obtained the geometrical interpretation, we need not carry the discussion further in detail. The large number of analytical results obtained in the theory of Fredholm equations may be easily given a geometrical interpretation in terms of this diagram.

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[6] See RANDALL and LONGTIN   Ind Eng. Chem , for graphical methods of carrying out this multiplication   To be published

[7] FREDHOLM   Proc Swedish Acad 57.   1900; Acta Mathematica 27.   1903

TRANSFORMATION OF COORDINATES

The transformation from one system of coordinate axes to a second was expressed by equation 22 of the second paper of this series.[a] Comparison of this equation with equation 7 shows that the transformation may be represented as a tensor operation,   .

$$\mathbf{v}' = \mathbf{E}' \ \mathbf{v}. \tag{9}$$

The tensor $\mathbf{E}'$ has as its components the quantities $e_{\lambda i}'$, each of which is the magnitude of the reduced component of a new base vector e_λ° in the direction of one of the original base vectors, e_i. In function space, the indices λ and i may be replaced by continuous variables ξ and x, with the result that the tensor $\mathbf{E}'$ is represented by the function $e(\xi, x)'$.

The use of tensors to represent the transformations of coordinates is well known in the vector and tensor analysis of ordinary 3-space. Delsarte[a] has shown that all euclidean transformations of coordinates in function space are special cases of the Fredholm operator, which is the most general form of the tensor operation. Thus the graphical methods of representing and operating with tensors which are presented above may be used in all of the transformations which are ordinarily necessary in obtaining auxiliary views of function space figures. They thus play an important role in the descriptive geometry of function space.

In the descriptive geometry of every-day experience, perspective projections are often useful. They may be obtained by means of what is known as a projective transformation of coordinates. The most general transformation of this type is expressed by the equation

$$\mathbf{v}' = \mathbf{E} \ (\mathbf{v} - \mathbf{a})/[b + \mathbf{c} \ \mathbf{E}(\mathbf{v} - \mathbf{a})], \tag{10}$$

in which b is a scalar, $\mathbf{a}$ and $\mathbf{c}$ are vectors, and $\mathbf{E}$ is a tensor, all being constants.

If the constant b is zero, the transformation projects function space onto a plane at a distance $1/|\mathbf{E} \ \mathbf{c}|$ from the point of view. The point of view is located at the end of the vector $\mathbf{a}$, while the line of sight is parallel to the vector $\mathbf{c}$ (i.e., the projection plane perpendicular to $\mathbf{c}$. If b were not zero, the same perspective view would be obtained by taking an auxiliary view of the transformed diagram, parallel to the vector $\mathbf{c}$. The mathematical properties of such transformations in function space have been studied by Dines.[b]

[a] DELSARTE   Compt Rend   186: 415, 1095   1928; Ann Fac Sci Toulouse [3] 20: 47   1928;   Rend Circ Mat Palermo   53: 135   1929
[b] DINES, L L   Trans Amer. Math Soc   20: 45   1919.

SUMMARY

An ordinary function space vector is a quantity having a singly infinite number of components. In addition to these, there are other types in which the components naturally separate into a finite number of sets such that corresponding to each component of a particular set there is one and only one component in each of the other sets. Examples of this type are bi-vectors and phase-space coordinates. The representation of any such composite vector is a generalization of the method here presented for bi-vectors, which consist in constructing a function space vector diagram for each set of components.

When the number of sets of components becomes infinite, the quantity becomes the function-space equivalent of a matrix. A matrix is represented by erecting an ordinate equal to the magnitude of the matrix component at the center of each square in rectangular array ordinarily used to represent the matrix. The representation of a function-space matrix is obtained by passing to the limit of an infinite number of squares contained within a rectangle of fixed dimensions. This results in representing the matrix by a function of two variables.

The tensor, which is a special type of matrix, is useful as an operator in obtaining ordinary and perspective projections of function space figures. It is, therefore, of particular importance in more advanced studies of the descriptive geometry of function space.

GEOPHYSICS.— *Geothermal gradient at Grass Valley, Calif. · A revision with a note on the flow of heat.*[1]   H. CECIL SPICER, U. S. Geological Survey. (Communicated by R. C. WELLS.)

The results presented herein are offered primarily as a revision of the computations that the writer made for W. D. Johnston, Jr.,[2] of temperature measurements made in the mines near Grass Valley, Calif. These results were also included in another recent publication.[3] A cursory reading of the later paper indicated some discrepancies, and in a subsequent study of the maps, text, and figure (fig. 1 of reference 2; fig. 8 of reference 3) the differences were located.

The 1,100 foot level of the Empire mine, altitude 2,200 feet, which is located at an average depth of approximately 300 feet below the

[2] JOHNSTON, W D, Jr   *Geothermal gradient at Grass Valley, California*   Journ Washington Acad Sci **22** (10) 267–271   1932; *Geothermal gradient of the Mother Lode belt, California*   Journ Washington Acad Sci **22** (14). 389–393   1932
[3] JOHNSTON, W D, Jr   *The gold quartz veins of Grass Valley, California*   U S Geol Survey Prof. Paper **194**: 21–22   1940.

surface was perhaps improperly chosen as the reference point for the earlier computations. Plate 35, reference 3, contains an error of altitude for the Empire 2,700 level; where the digits have been reversed so that the elevation should read 1,527 feet instead of 1,257 feet. This same level is designated the 2,200 at one place on the figure and is inconsistent with the two other 2,700 figures that are correct. However, these typographical errors do not change the computed results and are pointed out only in order that the altitudes, levels, and depths will be consistent in the revised results. Two other large differences in depth will be noted on comparing Table 1 of this paper with the earlier results; namely, Empire 3,400 and North Star 8,700 levels. Mine level altitudes supplied by W. D. Johnston, Jr., have taken the place of former figures given for these observations. Other minor differences between the depths in the two sets of results, have been disregarded.

A mean altitude of the ground surface above the included mine workings was obtained from the topographic map of the area,[3] and this altitude was used as the reference point for the present computations. This change of reference to a point 292 feet above the earlier

TABLE 1 —TEMPERATURE GRADIENT AT THE EMPIRE-STAR MINE, NEVADA COUNTY, CALIF [1]

Mine	Mine level	Altitude	Depth[2]		Observed temperatures		305-972 feet		305-3715 feet	
							Comp temp	Obs minus comp	Comp temp	Obs minus comp
		Feet	Meters	Feet	°C	°F	°F		°F	
Empire	1100	+2195	93 0	305	12 4	54 4	54 2	+0 2	54 6	−0 2
Pennsylvania	1000	2052	136 6	448	12 9	55 3	55 1	+0 2	55 4	−0 1
New York Hill	600	1899	201 5	611	13 1	55.6	56 0	−0 4	56 3	−0 7
North Star	1900	1825	205 7	675	13 6	56 4	56 4	0 0	56 6	−0 2
Pennsylvania	1400	1780	219 5	720	13 5	56 3	56 6	−0 3	56 8	−0 5
Pennsylvania	1700	1571	283 2	929	14 3	57 7	57 8	−0 1	57 9	−0 2
Empire	2700	1526	296 3	972	14 7	58 5	58 1	+0 4	58 2	+0 3
Empire	3000	1361	347 2	1139	15 3	59 5	59 0	+0 5	59 0	+0 5
Pennsylvania	2100	1358	348 1	1142	15 1	59 1	59 0	+0 1	59 1	0 0
Pennsylvania	2400	1238	384 7	1262	15 5	59 9	59 7	+0 2	59 7	+0 2
Empire	3400	1174	404 2	1326	15 5	59.9	60 1	−0 2	60 0	−0 1
Empire	3800	965	467 9	1535	16 6	61 8	61 3	+0 5	61 1	+0 7
Empire	4200	773	526 4	1727	17 2	62 9	62 4	+0 5	62 1	+0 8
Empire	4800	509	588 6	1931	17 4	63 3	63 6	−0 3	63 2	+0 1
Empire	5000	355	653 8	2145	17 9	64 3	64 8	−0 5	64 3	0 0
Empire	5400	+ 98	732 1	2402	19 0	66 2	66 3	−0 1	65 7	+0 5
Empire	5800	− 159	810 5	2659	19.5	67.1	67 7	−0 6	67 1	0 0
Empire	6200	− 414	888 2	2914	20 2	68.3	69 2	−0 9	68 4	−0 1
Empire	7000	− 928	1044.9	3428	21 6	70 8	72 1	−1 3	71 1	−0 3
North Star	8700	−1061	1085 4	3561	22 0	71 6	72 9	−1 3	71 8	−0 2
North Star	0000	−1215	1132 3	3715	22 4	72 3	73 8	−1 5	72 6	−0 3

[1] Observations made in 1930–31 by W D Johnston, Jr

[2] Depth below mean altitude of ground surface above mine workings. Mean altitude 2,500 feet.

Constants by least squares[a]

305–972 feet	972–3715 feet	1931–2914 feet
a = 52 50	a = 53 65	a = 53 41
b = 0 00573	b = 0 00505	b = 0 00516
1/b = 174 7	1/b = 198 2	1/b = 193 9
r = ±0 21	r = ±0 18	r = ±0 19
r_a = ±0 25	r_a = ±0 12	r_a = ±0 58
r_b = ±0 00036	r_b = ±0 00005	r_b = ±0 00024

305–1931 feet	1931–3715 feet	2402–3428 feet
a = 52 46	a = 53 79	a = 55 14
b = 0 00586	b = 0 00400	b = 0 00455
1/b = 170 7	1/b = 200 4	1/b = 220 0
r = ±0 23	r = ±0 13	r = ±0 10
r_a = ±0 15	r_a = ±0 21	r_a = ±0 36
r_b = ±0 00013	r_b = ±0 00007	r_b = ±0 00013

305–2914 feet	972–1931 feet	2014–3715 feet
a = 52 82	a = 53 09	a = 53 66
b = 0 00547	b = 0 00546	b = 0 00502
1/b = 182 9	1/b = 183 3	1/b = 199 2
r = ±0 25	r = ±0 21	r = ±0 07
r_a = ±0 13	r_a = ±0 35	r_a = ±0 38
r_b = ±0 00006	r_b = ±0 00025	r_b = ±0 00011

305–3715 feet	1535–2402 feet	305–3428 feet[a]
a = 53 03	a = 54 38	a = 53 38
b = 0 00528	b = 0 00478	b = 0 00518
1/b = 189 5	1/b = 209 1	1/b = 193 1
r = ±0 26	r = ±0 24	r = ±0 26
r_a = ±0 11	r_a = ±0 60	r_a = ±0 18
r_b = ±0 00006	r_b = ± 0 00035	r_b = ±0 00009

[a] °F /ft. ×1 82260 = °C /m
[a] Observations in Empire-Star only

computations causes the largest variation between the constants in the two computations. This change, however, places the reference point at the mean surface of the ground; the usual place of reference in earth temperature computations.

The same method was used to compute the constants in both instances; namely, the adjustment of a set of observations to a straight line by the method of least squares. The equation to be adjusted is

$$y = a + bx$$

in which

y	= temperature at a point of observation.
a	= computed annual mean temperature of the ground just below the surface.
b	= geothermal gradient in degrees Fahrenheit per foot.
x	= depth to an observed temperature.

$1/b$　= reciprocal geothermal gradient in feet per degree Fahrenheit.

r　　= probable error of an observed temperature y of weight unity.

r_a, r_b　= probable errors of the computed constants a and b.

The computations are summarized in Table 1.

The constants for some intervals not given in the previous paper have been added to this table. A separate set of constants for the observations made in the Empire mine were computed so that a comparison could be made with the other results that contain observations in nearby or connected mine workings. By comparing the gradient of the 305–3,715 foot interval, in which all of the observations were used, with the one for the 305–3,428 foot interval in the Empire alone, the observations are shown to be very homogeneous, and, therefore, the observed temperatures in close-by mines are believed to be definitely related to those in the Empire.

The observed annual mean temperature agrees closely with the computed temperature just below the surface of the ground in these results as well as in the previous ones. For the 305–972 foot interval, the observed air temperature exceeds the soil temperature by 0.1° F.; and for the 305–3,715 foot interval the excess of soil temperature is 0.4° F. The latter figure doubtless expresses the true soil temperature. The value of a is the point of intersection between the computed temperature line and the temperature axis, and reference to Fig. 1 shows this relation. The observed annual mean temperatures at Nevada City and Grass Valley have also been included in this figure and may be compared to the computed results.

The revised depth–temperature relations retain the slight concavity toward the depth axis as previously pointed out by Johnston.[2,3] The values of the geothermal gradient b decrease with increasing depth, and this is the indicator for a depth–temperature relation to be concave toward the depth axis.

An additional point on the flow of heat toward the surface may be of interest. All the observations were made in granodiorite, according to Johnston,[3] except the New York Hill 600, Empire 1100, and the North Star 1900, which were in porphyrite and diabase. The Empire 1100 observation was about 50–75 feet above the contact of the granodiorite. Neither in situ or laboratory tests have been made on these particular rocks, but results of the proper magnitude may be calculated from published figures of the thermal conductivity of similar materials as well as from computed thermal conductivities of the rocks of the area.

Some values of experimentally determined thermal conductivities
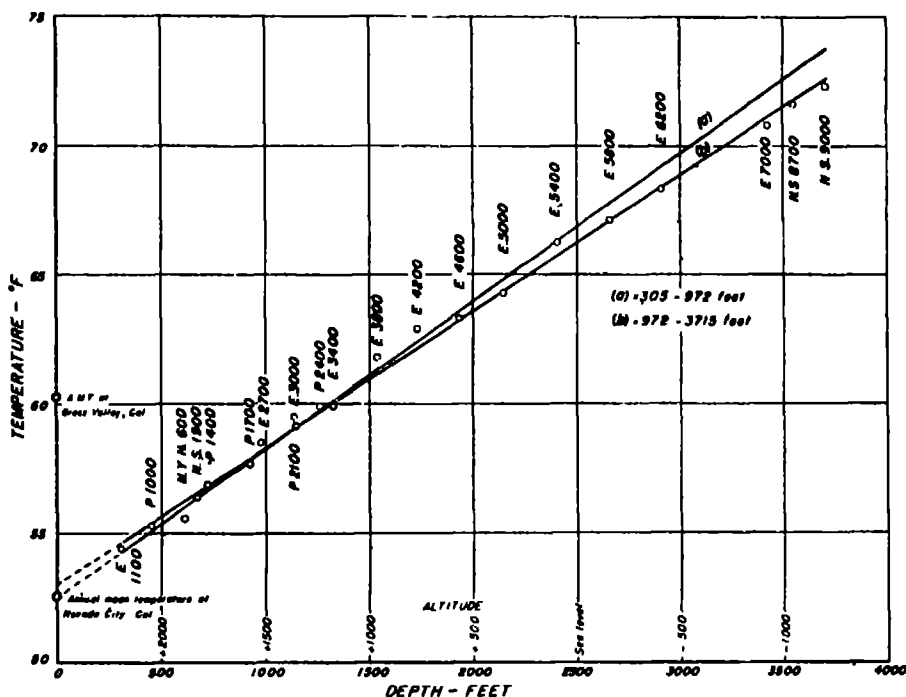
Fig 1 —Depth–temperature relation, Empire–Star Mine, Grass Valley, Calif

of rocks which are similar to those in the Grass Valley area are given in Table 2.

TABLE 2 --EXPERIMENTALLY DETERMINED VALUES OF THERMAL
CONDUCTIVITY OF ASSOCIATED ROCKS

Material	Thermal conductivity		Authority
	Range × 10²	Mean × 10²	
Diabase	5 02 5 44	5 20	Birch and Clark[1]
Augite porphyrite Hornblende porphyrite	2 77–8 57	4 84	Tadokoro[2]
Porphyrite Quartz monzonite		7 56	Birch and Clark[1]
Granite	5 60–8 30	6 99	Birch and Clark[1]
Granite	4 19–6 01	5 23	Tadokoro[2]
Granite porphyry		5 7	I C T[3]
Granite		8 1	Ingersoll and Zobel[4], Nancarrow[5]
Granodiorite		6 2	Interpolated from Birch and Clark[1] using granite and diabase

[1] BIRCH, F , and CLARK, H *Thermal conductivity of rocks and its dependence upon temperatures* Amer Journ Sci 238 529–558, 613–635 1940
[2] TADOKORO, Y *Determination of the thermal conductivity of rocks* Tôhoku Univ Sci Rep 10, 339–410 1921
[3] *International critical tables* McGraw-Hill Co , New York City
[4] INGERSOLL, L R , and ZOBEL, O J *Introduction to the mathematical theory of heat conduction* Ginn & Co , New York City (Out of print)
[5] NANCARROW, H A *Thermal conductivities of rocks* Proc Phys Soc London 45· 447–467 1933

Taking 5×10^{-3} as a representative value for the conductivity of the diabase and porphyrite, in which part of the observations were made, and combining it with the gradient for the 305–972 foot interval, the heat flow to the surface in the upper section is determined to be 5.2×10^{-7} cal/cm^2 sec. Using the conductivity 6×10^{-3} and combining it with the gradient for the 1,931–3715 foot interval, the heat flow in the lower granodiorite section is 5.5×10^{-7} cal/cm^2 sec. If the

TABLE 3 —COMPUTED VALUES OF THERMAL CONDUCTIVITY OF ASSOCIATED ROCKS

Material	Thermal conductivity	
	Parallel arrangement of elements	Series arrangement of elements
Diabase	0 0081	0 0061
Quartz porphyrite	0 0082	0 0059
Granodiorite	0 0084	0 0057

gradient computed for the entire range is used in combination with the conductivity 6×10^{-3}, the heat flow is then 5.7×10^{-7} cal/cm^2 sec.

The thermal conductivities for the parallel and series arrangement of mineral elements of the associated rocks given in Table 3 are calculated results. These theoretical values were obtained by calculating the norms and/or modes of the rocks from the chemical analyses[4] given in reference 3, grouping the constituents having similar thermal properties and obtaining the conductivity of each group from the results given by Birch and Clark,[5] then substituting in the formulas for computing the thermal conductivity of aggregates having either series or parallel arrangement of mineral elements. The results for the series arrangement of mineral elements are considered to be more nearly representative and they also compare more favorably with the values given in Table 2 for the experimental determinations on similar rocks. The flow of heat determined from the rounded 6×10^{-3} of the thermal conductivity from Table 3 would be the same as that previously given for the entire range of observations, namely, 5.7×10^{-7} cal/cm^2 sec. The three constituent rocks of the area appear to have very little difference in thermal conductivity, and a rounded figure of 6×10^{-7} cal/cm^2 sec. will closely approximate the flow of heat to the surface. However, as a probable upper limit for the flow of heat through the entire section, the conductivity for the parallel arrangement in granodiorite, 8.4×10^{-3}, may be used with the gradient for the 305–3,715

[4] CROSS, W., IDDINGS, J P , PIRSSON, L V , WASHINGTON, H S. *Quantitative classification of igneous rocks* Univ Chicago Press. 1903
[5] BIRCH, F., and CLARK, H *Thermal conductivity of rocks and its dependence upon temperatures* Amer Journ Sci **238:** 529–558, 613–635 1940.

foot interval thus giving the result 8.1×10^{-7} cal/cm² sec. for the flow of heat.

The figures obtained in these calculations of heat are low compared to the results of Bullard and Krige in South Africa and Benfield[6] in England. In South Africa the surface flow range obtained was $9.5 - 15.2 \times 10^{-7}$ cal/cm² sec., mean $11.6 \pm 0.09 \times 10^{-7}$ cal/cm² sec.; in England, $6.8 - 15.3 \times 10^{-7}$ cal/cm² sec., mean $9.8 \pm 0.17 \times 10^{-7}$ cal/cm² sec. If the conductivities of the rocks were measured either in situ or in the laboratory and found to be larger than those used in obtaining the results just given the values of heat flow would of course be larger. Over the potash-bearing area of New Mexico, Richardson and Wells[7] obtained 45 cal/cm² yr. for the flow of heat to the surface through the anhydrite and associated formations, or, converted to the units of this paper, 14.4×10^{-7} cal/cm² sec. The conductivity of the anhydrite and other rock was assumed to be 12.3×10^{-3}.

The somewhat lower heat flow near the surface is probably related to the larger infiltration of water near the surface.[8] In the first 1,000 feet of the Empire mine, about 670 gallons of water a minute are pumped to the surface, and this flow of water could conceivably be the main cuase of the lower temperature gradient and the slightly smaller heat flow in the upper section of the mine.

PALEONTOLOGY.—*Note on a vertebra of* Palaeophis *from the Eocene of Maryland.*[1] S. F. BLAKE, Arlington, Va.

The comparative rarity of fossil remains of snakes makes it desirable to place on record a nearly perfect anterior thoracic vertebra of *Palaeophis* which I collected in 1937 at the well-known Eocene locality at Popes Creek, Charles County, Md. The vertebra was found in the greensand at the very base of the cliff near its upper end, and is therefore to be referred to Zone 17, Woodstock member, Nanjemoy formation (the upper formation of the Pamunkey group). It is the first specimen of this genus to be found in Maryland, and the most nearly complete specimen so far found in this country.

The only Eocene snakes known from the east coast of the United

[6] BULLARD, E C   *Heat flow in South Africa* Proc. Roy. Soc. London, A173 (955): 474–502. 1939.
    KRIGE, L. J.   *Bore-hole temperatures in the Transvaal and Orange Free State.* Ibid.. 450–474.
    BENFIELD, A. E.   *Terrestrial heat flow in Great Britain.* Ibid.: 428–450
[7] RICHARDSON, L. T, and WELLS, R C   *The heat of solution of some potash minerals.* Journ. Washington Acad Sci. 20: 243–248. 1931.
[8] JOHNSTON, W D., Jr   *Op. cit*
[1] Received August 9, 1941.

States, according to Gilmore's monograph,[2] are four species of *Palae-ophis*. Three of these, *P. littoralis* Cope, *P. halidanus* Cope, and *P. grandis* (Marsh), are known altogether from only about 6 thoracic vertebrae from the Eocene greensands and marls of New Jersey (Manasquan marl, Vincentown lime, and (probably) Shark River marl). The fourth, *P. virginianus* Lynn, is known from two thoracic vertebrae, one fairly complete, the other very imperfect, collected by Dr. W. G. Lynn on the shore at Belvedere Beach, below the mouth of Potomac Creek, King George County, Va., almost directly across the Potomac River from Popes Creek. These specimens are ascribed to the Aquia formation (the lower formation of the Pamunkey group), which forms the bulk of the deposits at this place. Four additional species of *Palaeophis* are described from the Eocene of England, and one from the Eocene of Belgium. As is the case in most groups of
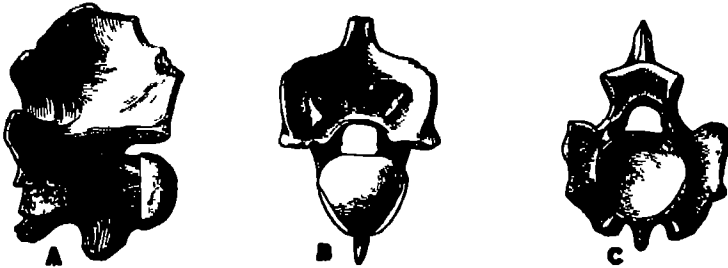
Fig 1 —*Palaeophis grandis* (Marsh)   Specimen from Popes Creek, Md   *A*, lateral view; *B*, posterior view, *C*, anterior view   Natural size   Drawn by Sydney Prentice

fossils known chiefly or entirely from vertebrae, there is doubt whether all the described species are actually distinct.

Gilmore temporarily retains the four described American species of the genus but hints his suspicion that the characters employed in his key are partly or wholly correlated with differences in position in the vertebral column. The vertebrae of the three New Jersey species are distinguished among themselves principally by differences in size, obviously not a good basis for specific distinction when their relative position in the backbone of a 15- or 20-foot snake is unknown, as is also the stage of maturity of the individuals from which they came. *Palaeophis virginianus* stands apart on at least two definite features, its single hypapophysis and its much less extensive neural spine, but these differences also might conceivably be due to differences in position in the vertebral column.

I have been able, in company with Dr. G. G. Simpson, to compare

[2] GILMORE, C. W   *Fossil snakes of North America*   Geol Soc. Amer Spec Pap 9: 4, 46–56.   1938.

the Maryland vertebra with two vertebrae in the American Museum of Natural History, apparently all that now exist of the three on which *Palaeophis littoralis* Cope was founded. One of these is the comparatively complete specimen figured by Cope, the other too imperfect to be of any value for comparison. The Maryland specimen is about twice the size of the better New Jersey one, but no structural difference of undoubted specific significance is evident. A single vertebra (U.S.N.M. no. 11753) from Vincentown, N. J., referred by Gilmore to *P. littoralis*, is so similar to the Maryland specimen that it is difficult to imagine any specific difference, but it is distinctly smaller.

The single known vertebra of *P. halidanus* Cope, of which I have seen only the illustration, is so fragmentary that satisfactory comparison is impossible, and Gilmore doubts that other specimens can ever be identified with it. The single known vertebra of *P. grandis* (Marsh), of which also I have seen only the figures given by Gilmore, has the hypapophyses represented only by scars and is otherwise more incomplete than the Maryland vertebra, as well as somewhat larger, but on the whole agrees so well with my specimen that it seems permissible to refer the latter to it, at least provisionally. At the same time, I wish to indorse the implicit suggestion in Gilmore's monograph that the three described species from New Jersey really represent only one, although the Virginian species may be distinct. As regards the New Jersey species, at any rate, whatever external or internal distinctive characters the snakes in question might have presented to a contemporary zoologist, the differences observable in their preserved remains are no greater than might be expected in different parts of the vertebral column of a single specimen of such size (around 20 feet) as these animals are supposed to have attained.

I am indebted to C. W. Gilmore for assistance in the preparation of this note, as well as for obtaining the services of Sydney Prentice to make the drawings that illustrate it. The specimen has been placed in the U. S. National Museum (no. 15888). It measures: Div. Vert. Paleont.).

Greatest height	33 8 mm
Width across presygapophyses	21 5 mm
Length of centrum (edge of glenoid cavity to end of condyle)	20 2 mm
Least width of centrum (near middle)	0 2 mm
Distance from top of zygosphene to lower margin of glenoid cavity	21 2 mm
Height of glenoid cavity	11 0 mm
Width of glenoid cavity	11 8 mm
Height of condyle	10 5 mm
Width of condyle	11 7 mm
Distance between extremities of pre- and postzygapophyses	21 6 mm
Distance between extremities of right and left postzygapophyses	20.1 mm
Height of neural canal in front	5 3 mm
Width of neural canal in front	8 7 mm
Greatest width of zygosphene	11.2 mm

BOTANY.—*Three new species of* Muhlenbergia.[1]   CHARLOTTE O.
GOODDING.   (Communicated by JASON R. SWALLEN.)

During recent study of the specimens at the United States National
Herbarium three new annual species of *Muhlenbergia* were found. One
species occurs only in Arizona, the second in Arizona, New Mexico,
Colorado, Texas, and Mexico, while the third is reported from Ari-
zona and Mexico. Invaluable assistance in the determination of ma-
terial and in the preparation of the manuscript was given by Jason R.
Swallen.

Muhlenbergia appressa C O Goodding, sp. nov.

Annua; culmi 10–40 cm longi, erecti vel decumbentes, ramosi, infra nodos
scabri vel hispiduli; vaginae striatae, firmae, marginibus membranaceis,
internodiis breviores, ligula 2–3 mm longa, hyalina, lacerata; laminae planae
vel plicatae, 1–4 cm longae, 1–2 mm latae, scabrae vel pubescentes; panicu-
lae 5–20 cm longae, 0.5–1 cm latae, saepe parte inferiore inclusa, ramis
appressis paucifloris; spiculae 4.5–6 mm longae; glumae 1–2 mm longae,
obtusae, integrae vel erosae; lemma 4.5–6 mm longum, scabrum, ad basim
dense pilosum; arista 10–30 mm longa, scabra, palea acuminata, scabra, ad
basim pilosa; granum fusiforme, 2 5 mm longum. Vaginae inferiores re-
ductae, spiculis clandestinis, glumae obsoletae, lemma 3 mm longum, scab-
rum ad basim pilosum, arista 5 mm longa; granum 2 mm longum, ovatum.

Annual; culms erect to decumbent at the base, 10–40 cm long, much
branched below, striate, scabrous to hispidulous below the nodes; sheaths
shorter than the internodes, striate, scabrous, firm with membranaceous
margins sometimes auricled; ligule thin, lacerate, decurrent, 2–3 mm long;
blades flat or folded, scabrous or puberulent, 1–4 cm long, 1–2 mm wide;
panicles numerous, as much as 20 cm long, 0.5–1 cm wide, green to purple,
very narrow, few-flowered, often included at the base, the branches and
pedicels closely appressed, spikelets slender, 4.5–6 mm long, the slender
pedicels 0.5–4 mm long; glumes 1–2 mm long or sometimes less, obtuse, en-
tire or erose, thin, pale, contrasting with the bright green scabrous nerve;
lemma 4 5–6 mm long, 3-nerved, scabrous above, densely pilose on the cal-
lus and margins at the base, awn 10–30 mm long, slender, flexuous, scabrous;
palea acuminate, scabrous, short pilose below; anthers 1.5–2 mm long, pur-
plish; grain fusiform, about 2 5 mm long. Cleistogamous spikelets common
in the lower reduced sheaths, glumes wanting, lemma about 3 mm long,
sparsely scabrous above, pilose on the callus and margins at the base, awn
about 5 mm long, grain 2 mm long, ovate.

This species is related to *M. microsperma* (DC.) Kunth, which differs in
having a more open panicle with more densely flowered ascending to spread-
ing branches, shorter ligule (1–2 mm long), and shorter lemma (2.5–3.5 mm
long or rarely less).

Type.—*Harrison & Kearney 1493* (U. S. National Herbarium no. 1296986),
Devils Canyon, Pinal or Gila County, Ariz , March 28, 1926.

Range.—Canyons and slopes of southern Arizona.

Specimens examined.—Devils Canyon, *Peebles, Harrison & Kearney 5085;*
mountains above Miami, *L. N. Goodding* in 1941; Camp Creek, Maricopa
County, *L. N. Goodding 23–41;* Pima Canyon, *Griffiths & Shear 2628.*

Muhlenbergia brevis C. O. Goodding, sp. nov.

Annua; culmi graciles, erecti, 3–20 cm alti, caespitosi, ramosi, infra nodos scabri vel hispiduli; vaginae compressae, carinatae, striatae, firmae, marginibus membranaceis, internodiis longiores; ligula 1-3 mm longa,hyalina, lacerata; laminae planae vel involutae, 0 5–4 cm longae, 1–2 mm latae, supra scabrae vel pubescentes, infra scabrae, paniculae 1- 12 cm longae, ca. 0.5 cm latae, saepe parte inferiore inclusa, ramis erectis usque ad 1 cm longis; spiculae 4–5 mm longae; glumae scabrae, quam flosculus breviores; gluma prima 1–3 mm longa, 2-nervia, minute vel profunde bifida; gluma secunda 1.5–4 mm longa, 1-nervia, acuminata vel setacea, lemma 4–5 mm longum, 3–5-nervium, scabrum, ad basim sparse pubescens; arista 10-20 mm longa, scabra; palea 4--5 mm longa, acuminata, scabra.

Annual; culms erect, 3–20 cm tall, slender, tufted, much branched below, scabrous to hispidulous below the nodes; sheaths compressed, keeled, striate, firm with membranaceous margins, usually longer than the internodes, the lower ones often spreading; ligule 1–3 mm (usually about 2 mm) long, thin, lacerate, often auriculate, blades flat to involute, 0.5–4 cm long (mostly 2–3 cm), 1–2 mm wide, scabrous or puberulent above, scabrous below, with white cartilaginous midrib and margins, panicles 1–12 cm long, less than 0.5 cm wide, often included at the base, rather densely flowered, pale green tinged with purple, the branches erect, as much as 1 cm long; spikelets slender, 4–5 mm long; glumes scabrous, variable, shorter than the floret; first glume 1 -3 mm long, 2-nerved, minutely to deeply bifid, the slender teeth sometimes widely spreading; second glume 1 5–4 mm long (usually 2–3 mm), 1-nerved, narrow, acuminate to setaceous; lemma lanceolate, 4–5 mm long, prominently 3-nerved (rarely 5-nerved), scabrous especially on the nerves, sparsely to rather densely appressed pubescent between the nerves toward the base; awn 10–20 mm (rarely less) long, slightly flexuous, scabrous; palea 4–5 mm long, acuminate, scabrous, grain fusiform, 2 5 mm long

This species is closely related to *M. depauperata* Scribn , which differs in having a shorter lemma (3–3.5 mm long) with a shorter awn (5–10 mm long or less) and glumes about as long as the floret.

Type.—Metcalfe 671 (U S National Herbarium no. 495644), Mogollon Mountains, on Mogollon Creek, Socorro County, N Mex , September 8, 1903.

Range.—Open ground at higher elevations, Colorado and Texas to Arizona, south to the Federal District, Mexico.

Specimens examined.--ARIZONA: Bowie, *Jones* in 1884 COLORADO: Rio Grande Forest, Conejos County, *Kutzleb* (U S. Forest Service *66111*). NEW MEXICO: Black Range, *L. N Goodding M-271, L N & C Goodding M-377, Metcalfe 1362*, Datil National Forest, *Talbot 47*, Mimbres Mountains, *L. N. & C. Goodding M-380* no locality given, *Wright 2017* TEXAS· Mount Livermore, *Hinckley 523*. CHIHUAHUA. Sanchez, *Hitchcock 7664*. DURANGO: Sandia Station, *Pringle 13634* SAN LUIS POTOSÍ: San Luis Potosí, *Schaffner* in 1877 and 1879. FEDERAL DISTRICT. Churubusco, *Orcutt 4311*.

Muhlenbergia pectinata C. O. Goodding, sp. nov.

Annua; culmi 10–25 cm longi, erecti vel decumbentes, ad nodos inferiores radicantes, ramosi, graciles, glabri vel infra nodos scabri; vaginae internodiis longiores, striatae, in ore plusminusve pilosae, saepe marginibus ciliatis; ligula hyalina, erosa vel ciliata, ca. 0.5 mm longa; laminae planae

vel involutae, pubescentes vel pilosae, 1–6 cm longae, 1–2 mm latae; paniculae 2–12 cm longae, ca. 0.5 cm latae, exsertae vel parte inferiore inclusa, ramis 0.5–4 cm longis, appressis, ad basim floriferis; spiculae 3.5–4.5 mm longae; glumae 1.5–3 mm longae, abrupte acutae vel acuminatae, aristatae; lemma 3–5 nervium, nervis lateralibus scabris vel ciliatis, callo pubescente; arista 10–30 mm longa, gracilis, flexuosa; palea acuminata lemma aequans.

Annual, culms 10–25 cm long, leafy, erect to decumbent, sometimes rooting at the lower nodes, slender to filiform, freely branching, glabrous to scabrous below the nodes, angular, usually square in cross section; sheaths commonly longer than the internodes, striate, more or less pilose at the throat, the margins often ciliate; ligule thin, erose to ciliate, about 0 5 mm long; blades flat to involute, divergent, pubescent to sparsely pilose, 1–6 cm long, 1- 2 mm wide; panicles numerous, very narrow, exserted or more often included at the base, 2–12 cm. long, about 0.5 cm wide, the branches 0.5- 4 cm long, appressed, floriferous from the base or nearly so; spikelets narrow, terete, 3.5–4.5 mm long; glumes equal or unequal, 1 5–2 mm or sometimes 3 mm long, prominently 1-nerved, scabrous on the nerve, abruptly acute or acuminate, commonly aristate, the awn usually about one-half the entire length, lemma prominently 3-nerved, with usually 2 intermediate nerves, scabrous to prominently ciliate on the lateral nerves, the callus appressed pubescent; awn 10–30 mm long, slender, flexuous; palea long-acuminate, as long as or slightly longer than the lemma.

This species is related to *M. ciliata* (H.B K.) Kunth, which differs in having spreading panicle branches and shorter lemmas (2–2.5 mm long), shorter awns (3–12 mm long) It is also closely allied to *M. tenella* (H B.K) Trin , which differs in having smaller spikelets (2–2.5 mm long).

Type.—*Pringle 1745* (U S National Herbarium no. 995478), moist ledges of the barranca near Guadalajara, Jalisco, Mexico, November 1, 1888.

Range.—Moist rocky hillsides of southern Arizona, south to Jalisco, Mexico.

Specimens examined —ARIZONA: Mule Mountains, Cochise County, *L. N. Goodding M-348, L. N. & C. Goodding M-406;* Sycamore Canyon, Santa Cruz County, *L N Goodding M-318, M-375, A-9386*. SONORA: Canyon de Huépari, north of Aribabi, *Harvey 1742* CHIHUAHUA: Batopilas, *Palmer* in 1885. DURANGO· Vicinity of Durango, *Palmer 719* in 1896. JALISCO: Chapala, *Holway 3479*, Guadalajara, *Palmer 404* and *481* in 1886; Tequila, *Pringle 5395;* Zapotlan, *Hitchcock 7257.*

PALEOBOTANY.—Pinus *and* Quercus *in the Chesapeake Miocene.*[1]
EDWARD W. BERRY, Johns Hopkins University.

In 1936 I described a pine cone from the Calvert Cliffs Miocene under the name of *Pinus collinsi,*[2] naming it after the collector. Obviously the specimen furnished few features for a specific diagnosis, or for useful comparisons with other described species, either recent or fossil. I remarked on the apparent scarcity of land plants in these shallow-water marine sediments. In the past few years detailed examination of these strata by Dr. R. E. Lee Collins and by Dr. Charles T.

Berry has demonstrated that remains of land plants, although uncommon as might be expected, are not nearly so rare as had been assumed, and incidentally, the same remark might be made of land animals. It is the purpose of the present note to comment on some additional occurrences.

Pinus collinsi Berry

These cones are in the same poor state of preservation and with the same lack of specific characters as the type Sometimes they are fairly complete. At others they are badly broken up, or not much more than the macerated cone axis is preserved. Superficially they all appear to belong to the single species, but this is incapable of proof.

To date they have been collected from the following localities and horizons: 1.7 miles south of Plumpoint, Zone 11 of Calvert formation (type); 1½ miles south of Plumpoint, Zone 10 of Calvert formation, ¼ and ½ mile north of Governors Run, Zone 14 of the Calvert formation; 2 miles south of Cove Point, Calvert County, St Marys formation. The foregoing are all in Maryland In addition, similar cones have been found near the south end of Stratford Cliffs (Nomini), Westmoreland County, Va., in the Calvert formation

At the locality 1½ miles south of Plumpoint, the cones are associated with driftwood of *Pinus* and fragments of dicotyledonous leaves. Figs 1 and 2 show the usual condition of these cones. The lignite to which they have been altered is structureless, and if not treated before drying with gum arabic, paraffin, or duco they disintegrate very rapidly.

Quercus sp.

Several acorns of some species of oak were collected in 1937 at Stratford Cliffs, 1 mile below the mouth of Popes Creek, Westmoreland County, Va., by Charles T. Berry. They are about 1 5 cm in length by 1 cm in diameter and afford no diagnostic features

The following species of oaks, based upon leaves, were described in 1916 from near shore phases of the Calvert formation at Richmond, Va., and from two localities in the District of Columbia near Washington[2]. *Quercus calvertonensis*, *Quercus chapmanifolia*, and *Quercus lehmani*. The first was compared with the modern *Quercus alba*, the second with *Quercus chapmani*, and the third with *Quercus emoryi*. If any conclusion can be drawn from these most similar living relatives, which is perhaps doubtful, the Miocene *Quercus chapmanifolia* and *Quercus lehmani* should have had acorns smaller than the present fossil. It would seem that *Quercus calvertonensis*, though a smaller-leafed form than the existing *Quercus alba*, was the only one of the Miocene species based on leaves with which the fossil acorn should be correlated, although this is, of course, problematical.

The known Miocene flora of the middle Atlantic slope is one of cypress-

² BERRY, EDWARD W , U S Geol Surv Prof Paper 98: 61–73, pls 11, 12 1916.

swamps, sand dunes, and beach ridges. Whether these ecological groups are merely the normal reflection of the coastal zone in shallow marine sediments or whether they are of wider climatic significance can not be determined from present information. That there was less runoff from the land, or at least less terriginous material in the water, thus permitting the accumulation of the diatomaceous beds that are so prominent a feature of the earlier Miocene sediments in this region, is certainly well established.
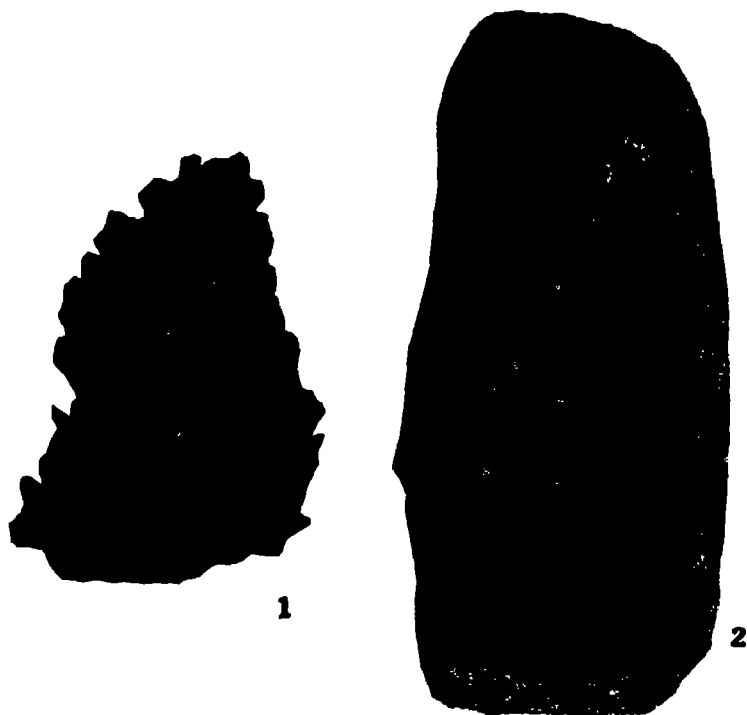
Fig 1 —*Pinus collinsi* Berry, from 1½ miles south of Plumpoint, Md.
Fig 2 —*P collinsi* from south end of Stratford Cliffs, Va

The known flora appears, as judged by present-day conditions, to be about normal to the latitude. There is considerable evidence from the little that is known about the Tertiary floras of the eastern United States that the Miocene climate was somewhat cooler than that of the Eocene, and there is overwhelming evidence in the fossil floras of other parts of the world, notably in the Mississippi embayment, northern Europe, and the Arctic, that this was a world-wide condition. There is also considerable evidence that the contemporaneous marine fauna of the Calvert is a cooler-water fauna than those of the earlier Tertiary and also, although to a lesser degree, than those of the later Tertiary.

ZOOLOGY.—*New species and distribution records of diaptomid copepods from the Marsh collection in the United States National Museum.*[1]   MILDRED STRATTON WILSON.   (Communicated by WALDO L. SCHMITT.)

This paper is based on the material concerning the genus *Diaptomus* that accumulated in the collection of Dr. C. Dwight Marsh following the publication of his paper on the distribution of the genus in 1929. His studies on other fresh-water calanoids were entirely included in the posthumous paper published in 1933. There were found in the collection, in addition to new distribution records, slides of two undescribed species. Of these, the one from a collection made in Guatemala is represented by several slides. The name *D. amatitlanensis*, given by Dr. Marsh in his notes, is retained. The other species, from a collection made in New Jersey, is named *D. lighti* for Prof. S. F. Light, of the University of California. *D. lighti* is represented by a unique male specimen, unfortunately incomplete as regards the right antennule. Since the specimen shows no indication of abnormality and is distinctly different from other related diaptomids, it is being designated a new species.

There was also found a mounted specimen of *D. augustaensis* Turner, 1910, hitherto known only from the original collection. Since Turner's description was not complete, especially as regards the left fifth leg and the modified right antennule of the male, it is redescribed on the basis of the newly found specimen.

DISTRIBUTION RECORDS

Dr. Marsh included most of the known information about the distribution of *Diaptomus* in his paper on the distribution of the genus (1929). Later (1931) he published a paper on collections made in El Salvador, which reported finding there *D. marshi* and *D. siciloides*. Wright had also found *D. siciloides* in Lake Erie, and his material is a part of the Marsh collection in the National Museum. Marsh mentioned (1931) that Bajkov also found *D. siciloides* in Lake Winnipegosis, Manitoba. Bajkov (1929) added further distribution records for Manitoban lakes, as follows: *D. ashlandi, D. leptopus, D. shoshone, D. sicilis*, and *D. tenuicaudatus*. Of these, a mounted specimen of *D. ashlandi* is in the Marsh collection.

Unpublished records of collections made by or presented to Dr.

Marsh follow. The notes concerning these collections are very brief, and complete information is often lacking.

D ashlandi Marsh· Klamath Lake, Klamath Falls, Oreg , collected by C D Marsh, August 26, 1929

D augustaensis Turner: Chapel Hill, N C , collected by R E Coker, May 1931

D bacillifer Kölbel: Tundra pond on east side of Lake Harbour, southern coast of Baffin Land, collected by F. Johansen, August 23, 1927

D clavipes Schacht: Ada, Pontotoc County, southern Oklahoma, collected by J G Mackin, contributed by S Wright

D eiseni Lilljeborg· Tundra ponds at Port Burwell and Wakeham Bay, Hudson Strait, collected by F Johansen, 1927

D minutus Lilljeborg White Lake, N C , collected by R E. Coker, first record of occurrence south of Indiana (Marsh 1929); Newton, Mass , collected by C B. Wilson Wilson (1932) has reported *D minutus* from the Woods Hole region

D. oregonensis Lilljeborg· Flathead Lake, Mont.

D. sanguineus Forbes; Ada, Pontotoc County, southern Oklahoma, collected by J. G Mackin, contributed by S Wright.

D. sicilis Forbes Flathead Lake, Mont , collected by R T Young, August 10, 1929; Gabas road (?) near Midland, Oreg , collected by C D Marsh, August 27, 1929. The most western location reported for *D sicilis* has been Yellowstone Park (Marsh 1929).

SYSTEMATIC DISCUSSION

Diaptomus amatitlanensis, n. sp   Fig 1, *a–d*

Specimens examined.—Thirty-six mounted specimens, 17 female, 19 male, Marsh slides 5402–5405 and 5409–5419. Collected by Chancey Juday in Lake Amatitlan, Guatemala, February 5, 1910. Male holotype, U S. N. M. no. 79366, Marsh collection, slide 5409.

Description.—Metasome convex in dorsal profile, tapering slightly posteriorly. Urosome relatively short, furcal setae short; furca ciliated on both inner and outer margins Antennules reaching to end of furca.

Female· Length about 1.4–1 5 mm, exclusive of furcal setae. Last segment of metasome bearing a blunt dorsal tooth, variable in size; posterolateral projections inconspicuous, rounded, bearing two spines; spine of dorsal side minute, sharply pointed, that of lateral tip stout, somewhat curved. Spines of genital segment of urosome stout and long, second segment shortened, right side produced into prominent spine-like caudal process. *Fifth legs:* Relatively slender, with long, stout basal spines. Third segment of exopodite distinct, its spine twice the length of seta. Spine of second segment short; claw almost as long as inner margin of first segment, nearly straight; outer margin of claw bearing two slender teeth or none; inner margin with ten to eighteen stout teeth on anterior surface. Endopodite half the length of inner margin of first segment of exopodite, bearing two short setae, inserted subapically and extending slightly below the tip, lateral seta one-third longer than median; tip truncate, with a narrow asymmetrically placed groove bordered by a line of slender hairs.

Male: Length about 1.25–1.4 mm, exclusive of furcal setae. Left antennule with usual setal formula. Right antennule markedly swollen, major spines on segments 10, 11, and 13; those on 10 and 11 slender, slightly curved, length less than width of segments; spine on segment 11 about one-

third longer than that on segment 10 Spine on segment 13 large, almost twice as long as width of segment, broad at base, tapering, obliquely directed. Segment 14 with conspicuous, obliquely directed spinous process arising at proximal angle, and almost as long as spine on segment 13 Small, distally directed spinous processes at mid-margin of segments 15 and 16. Processes of segments 14, 15, 16 and depressed process of segment 17, accompanied by modified setae, stiff, slender and blunt-ended. Process on antepenultimate segment tapering, slightly outcurved, length less than that of penultimate segment. *Fifth legs.* Relatively narrow, left leg reaching to slightly beyond distal end of first segment of right exopodite Basal spines long and stout. *Right leg:* Basal segment about as long as wide, margins rounded. Second basal segment much longer than wide, lateral hair at distal fourth, a somewhat diversified process ending in a rounded lobe projects transversely on the distal posterior face First segment of exopodite short, wider than long, outer margin longer than inner, terminating in distally directed lobe, running across the posterior face of the segment from near outer to near inner margin is a triangularly elongate ridge with its distal extremity narrowed; a small rounded lamella projects from the distal border of the segment. Second segment broad, length less than twice width; midway of the segment, beginning at the medial margin, is a straight, obliquely directed ridge, lateral spine near distal end, relatively slender, length less than width of segment, distal half curved. Claw about as long as rest of leg excluding first basal segment, strongly curved in distal half, inner margin finely denticulate. Endopodite short and wide, reaching slightly beyond first segment of exopodite, bearing laterally on inner margin (rarely on outer) a slender, distally-directed seta, tip truncate, set with circular line of slender hairs *Left leg:* Basal segments subequal, longer than wide; lateral hair slightly in front of distal third of second segment. Exopodite less than one-half length of basipodite; first segment longer than second, pad large, bearing short slender hairs. Processes of apical segment very small, the distal broad, blunt, not set off sharply; the lateral spine-like, slender, tapering and curved, proximal pad set with long slender hairs; distal pad extending nearly to tip of distal process, set with coarse recumbent hairs. Endopodite narrow, reaching slightly beyond first segment of exopodite; bearing laterally a slender seta; tip with an asymmetrically curved line of slender hairs.

Taxonomic position.—*Diaptomus amatitlanensis* belongs to the subgenus *Mastigodiaptomus* Light, 1940, and resembles the other included species, *D. albuquerquensis* Herrick and *D purpureus* Marsh in all the major subgeneric characters. It is interesting that *D albuquerquensis* appeared in the same collection from which the type species of *D. amatitlanensis* has been described (Juday, 1915).

D. amatitlanensis is seemingly most closely related to *D. purpureus* in that the lateral spine of the right fifth leg of the male is short, while in *D. albuquerquensis* it is comparatively much longer. The setae of the left leg of the female are intermediate in length between those of *D. albuquerquensis* and *D. purpureus* It differs distinctly from both other species in the absence of a hyaline lamella on the medial border of the second basal segment of the male right leg and in the broad, bulging second segment of the exopodite of the right leg of the male.

<div style="text-align:center">**Diaptomus lighti,** n. sp.   Fig 1, *h–j*</div>

Specimens examined.—Unique male holotype, U.S.N.M. no. 79368, Marsh
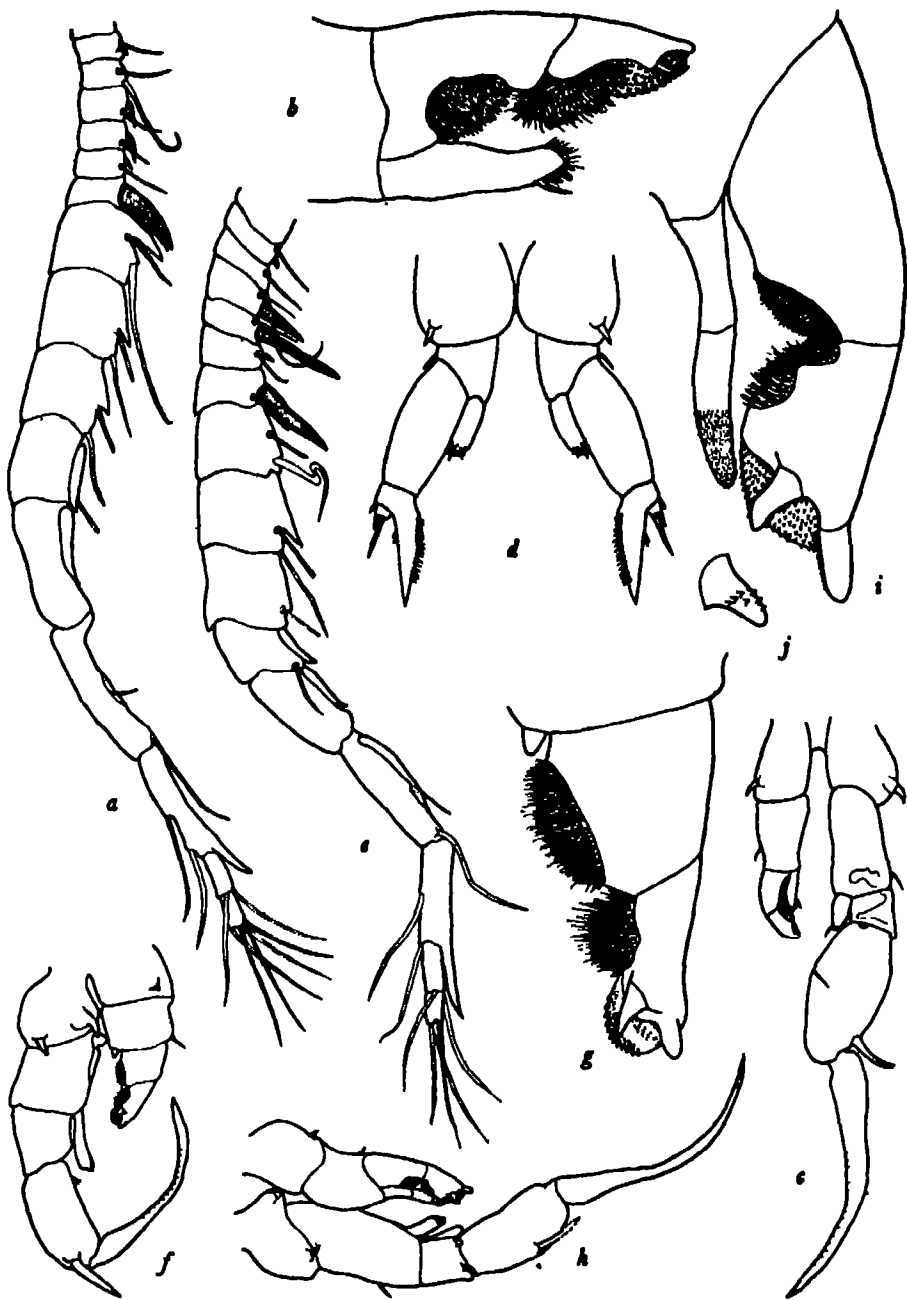
Fig. 1 —a-d, *Diaptomus amatitlanensis*, new species: *a*, Right antennule (male); *b*, left fifth leg (male), anterior view; *c*, fifth pair of legs (male), posterior view; *d*, fifth pair of legs (female) *e-g*, *Diaptomus augustaensis e*, Right antennule (male); *f*, fifth pair of legs (male), anterior view; *g*, left fifth leg (male), anterior view. *h-j*, *Diaptomus lighti*, new species: *h*, Fifth pair of legs (male), anterior view; *i*, left fifth leg (male), anterior view; *j*, proximal process of second segment of exopodite of left fifth leg (male), inside.

collection, slide 5355. Collected by Dr. C. D. Marsh in Big Timber Creek, Gloucester, N. J., September 19, 1931.

Description.—Female unknown.

Male: Length 1.75 mm, exclusive of furcal setae. Urosome relatively long, segments subequal in length, distal two abruptly narrowed. Antennules not reaching to end of furca; left with usual setal formula, three on segment 2, two each on segments 9, 11, and 22–24, five on segment 25, one on all others. Right antennule missing beyond third segment, showing evidence of having been broken prior to collection. *Fifth legs:* Elongated; left leg reaching to slightly beyond distal end of first segment of right exopodite. Spines of first basal segments short and slender. *Right leg:* Basal segment short and broad, rounded on outer margin; inner margin with broad, distally directed, spine-like lamella on distal posterior face Second segment twice as long as broad; inner margin rounded; outer margin incurved proximally; hair short, at distal third of segment. First segment of exopodite subquadrate, straight-sided, distal lateral corner ending in a rounded, distally directed lobe, next to this lobe on the anterior face and overlying the next segment, is a longer clawlike lamella, curving outward, at inner distal angle on the posterior face is a small rounded lamella; running along the entire inner margin is a hyaline lamella with widened, tonguelike free end, projecting beyond the distal angle of the segment. Second segment about twice as long as broad, outer margin convex, lateral spine slightly in front of distal third of segment, length more than half diameter of segment, somewhat curved; in specimen described, the distal half of spine is bent in a right angle to the proximal so extent of curvature cannot be determined. Claw longer than the rest of exopodite. Endopodite short, not reaching distal end of first segment of exopodite, acuminate, distal surface minutely setose *Left leg·* First basal segment subquadrate; inner face of second segment strongly convex, longer than outer, exceeding width of segment; outer margin concave, hair short, near distal end. Exopodite narrowed; first segment longer than second, outer face longer than inner; pad set with short, fine hairs. Second segment with inner face distinctly rounded, proximal pad with long slender hairs, distal pad set with short spinelets; processes short, subequal, digitiform; terminal distally directed, armed with inner marginal row of short setae; lateral process directed somewhat obliquely, armed on distal half of posterior inner face with rows of spinelets directed outward so that the tips of the outer spinelets project beyond the proximal margin of the process. Endopodite long, extending beyond middle of second segment of exopodite, 2-segmented, distal end blunt, dentate.

Taxonomic position.—*D lighti* clearly belongs to the subgenus *Leptodiaptomus* Light, 1938. The characters of the left exopodite of the male fifth leg fit the diagnosis given for that group. It differs from any other member of the group in the shape, size and attachment of the hyaline lamella on the inner margin of the first segment of the right exopodite This lamella, undoubtedly homologous with that in a similar position in many of the other species of the group, most closely resembles that of *D. signicauda.* It differs in being broader, less rounded distally, and in being attached only along the margin of the segment. The species is not only considerably larger than *D. signicauda,* but is large for the group as a whole. *D. lighti* is uniquely distinguished by the distinct claw-like lamella on the anterior face of the first segment of the right exopodite.

Diaptomus augustaensis Turner, 1910   Fig 1, *e–g*

Specimens examined.—Unique male specimen, Marsh slide 5317. Collected by R. E. Coker at Chapel Hill, N. C., May, 1931.

Description.—*Male:* Length approximately 2.5 mm (measurements based on dissected specimen). Left antennule with usual setal formula Segments 14–16 of right antennule markedly swollen, major spines on segments 10, 11, and 13 conspicuous, straight, longer than width of segments; that on 11 longest, almost twice length of that on segment 10; spine on segment 13 widest, almost as long as that on segment 11 Large, distally directed spinous process on distal third of segment 15. Process of antepenultimate segment tapering, longer than penultimate segment. *Fifth legs·* Basal spines short and stout. *Right leg.* First basal segment about as long as broad, margins rounded; large hyaline lamella on distal half of anterior inner surface, broad at base, terminating in curved distally directed process. This process partially overlies a hyaline lobe on the proximal inner margin of the second segment. Inner margin of second segment longer than outer, lobe extended as narrow hyaline border for two-thirds of its length. First segment of exopodite narrowed distally, outer margin longer than inner. Length of second segment more than twice width, outer margin concave; prominent spine at proximal fourth of inner margin Lateral spine close to distal end, stout, slightly longer than width of segment. Claw longer than exopodite, strongly curved, denticulate on inner margin Endopodite slender, one-fourth longer than first segment, inner margin setose in distal fourth, terminating in short rounded process. *Left leg:* Basal segments subequal in length, wider than long. Lateral hair at distal angle of second segment First segment of exopodite almost as long as wide, pad narrow with short, slender hairs; apical segment longer than wide, terminal process short, digitiform, lateral process a flat, broad, curving spine, armed on distal half of upper margin with short, stiff setae; pads large, proximal set with long slender hairs, distal with rows of conspicuous, heavy spinelets. Endopodite rudimentary

Taxonomic position.—*D augustaensis* clearly belongs to the subgenus *Hesperodiaptomus* Light, 1938, as indicated by the flat, curving, spinelike proximal process of the terminal segment of the left fifth leg of the male and the distal location of the lateral spine of the second segment of the exopodite of the right leg; the presence of a third segment in the exopodite of the fifth leg of the female (Turner, 1910); and the long spinous process on the antepenultimate segment of the right antennule of the male. It differs markedly from the other species of the subgenus in numerous particulars, notably the relatively large blunt spine on the inner face of the second segment of the exopodite of the right fifth leg of the male, the unusual hyaline membranes of the first and second basal segments of the same leg, and in the rudimentary endopodite This endopodite may be variable in character. A first glance at Turner's drawing in the description of the type makes it appear that the endopodite is longer than noted in the specimen herein described, but if the drawing is reconstructed so that the endopodite bears its proper relationship to the second basal segment, instead of arising as it seems to as a part of the first basal segment, it would appear to be also very much reduced Turner's description of the species refers to it as a "small, slender species," but the specimen herein described is comparatively large, as are many other species of the subgenus.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

369TH MEETING OF THE BOARD OF MANAGERS

The 369th meeting of the Board of Managers was held in the Library of the Cosmos Club on Friday, October 3, 1941. President CLARK called the meeting to order at 8·05 P.M , with 14 persons present, as follows. A. H. CLARK, F. D. ROSSINI, H. S RAPPLEYE, J. H KEMPTON, F. C. KRACEK, J E. GRAF, F H. H. ROBERTS, JR , F G. BRICKWEDDE, H B. COLLINS, JR., F. M. SETZLER, H L CURTIS, L. W. PARR, C. L GARNER, and, by invitation, R. J. SEEGER

The minutes of the 368th meeting were read and approved.

The President announced the following appointments· R J SEEGER, to be the Academy's delegate to the 175th anniversary celebration of Rutgers University, at New Brunswick, N. J , on October 9 to 11, 1941; C. L. GARNER (chairman), R. E. GIBSON, L. V. JUDSON, W. C LOWDERMILK, P. A. SMITH, and CHARLES THOM, to constitute the Committee on Meetings, until May, 1942

The Board considered and elected to membership one resident person.

The Committee to Publish the Directory for 1941, H. S. RAPPLEYE and F. D. ROSSINI, presented its report as follows:

In accordance with the action taken by the Board of Managers at its meeting on March 14, 1941, the 1941 Directory of the Academy and its Affiliated Societies was produced by the photolithographic process, in the usual 6 by 9 inch size with a red cover, and with a new form of contents. In the lists of members of the affiliated societies, the names of those persons who are also members of the Academy are marked with an asterisk.

In the production of the 1941 Directory, the master pages of the copy in its new form were typed by a private individual under special contract, in order to provide for close contact with the work and to make possible changes in copy at a minimum of cost. The job of planographing and printing

and binding was let to the A. L. Sauls Planograph Co., 909 E Street, NW., Washington, D. C., the lowest of four bidders. The Directory was distributed on September 1, 1941.

There occurred in the 1941 Directory two important errors which should be guarded against in future editions. One of these was an error of omission by the Committee and the other was an error of commission in the binding of the book, as follows: (1) Page numbers were inadvertently omitted from the contents page; (2) a number of the pages in the book are misaligned. To compensate for the latter error, the A. L. Sauls Co. made an allowance of $12 in the cost of producing the Directory

The cost of producing 1,000 copies of the 1941 Directory for the Academy was as follows:

Solicitation and preparation of the copy for the 19 affiliated societies	.	$ 16.29
Preparing the master copy by typing		78.87
Proof-reading the master copy	.	16.65
Planographing, printing, and binding	$192.40	
Less allowance for misalignments of pages	12 00	180.40
Total		292.21

By arrangement with the printer, additional copies of the Directory, over and above the 1,000 provided for the Academy, were prepared at a cost of $9.36 per hundred, for distribution on prepublication order to the affiliated societies at $10.00 per hundred, as follows.

Philosophical Society	275 copies		$27.50
Botanical Society	100	"	10.00
Institute of Radio Engineers	100	"	10.00
Anthropological Society	50	"	5.00
Total	525	"	52.50
Cost to the Academy			49.14
Profit to the Academy on these 525 copies			3.36

The net cost to the Academy of the 1941 Directory is therefore $288.85, and, since the Committee was allotted $350 for the 1941 Directory, there will remain, when the accounts are settled, an unexpended balance of $61.15.

On the basis of its experience with the 1941 Directory, the Committee wishes to recommend two changes for the next edition of the Directory:

(1) The booklet should be flat-stitched instead of saddle-stitched, even though the cost will be somewhat greater. There are too many pages in the Directory to make saddle-stitching satisfactory.

(2) The master pages should be prepared with the new, large character, bold-face type now available on special typewriters for photolithographic work, instead of with the type on ordinary typewriters. A sample of how this special bold-face type would appear when reduced to the size used in the 1941 Directory is attached in the form of a copy of page 41 of this Directory. The corresponding page from the 1941 Directory is attached for comparison.

The Committee also wishes to recommend that the Board of Managers authorize the President to appoint a Committee to consider the following questions with regard to future editions of the Directory:

(1) Should the Directory be published annually instead of biennially?

(2) Should the affiliated societies be asked to contribute a nominal sum to the cost of the Directory? For example, for those societies giving lists of members, the assessment might be 1½ or 2 cents per member, or perhaps $2 for each printed beyond the first.

(3) Should the duties of the Board of Editors be redefined to include all publications of the Academy? This would bring the preparation of the Directory under their jurisdiction.

The Board accepted this report and authorized the appointment of a Committee to Consider the Policy for Future Editions of the Directory.

The Secretary presented the following information concerning the membership: Deaths, 5; acceptances to membership, 7; qualified for membership, 9; retirements, 2. The status of the membership as of October 2, 1941, is as follows:

	Regular	Retired	Honorary	Patrons	Total
Resident	433	33	3	0	469
Nonresident . .	131	16	13	3	163
Total	564	49	16	3	632

The Treasurer reported that, in accordance with instructions from the Executive Committee, the funds on deposit in a savings account with the American Security and Trust Co. were placed on deposit in two accounts in federally-insured savings and loan associations, as follows: $4,000 in the First Savings and Loan Association, currently paying 3 percent interest, and $4,500 in the Northwestern Savings and Loan Association, currently paying 3½ percent interest. The following changes in investments were reported: The principal amount, $4,000, of real-estate notes of the Ell and Kay Investment Co., on apartment-house property at 5420 Connecticut Avenue, will be paid to the Academy on October 15, 1941, the Butler real-estate notes on garage property at 1707 L Street, NW., having a face value of $2,000, will, within 30 days of September 19, 1941, bring $1,200 (less commission) to the Academy, as a result of the trustees for the note holders being forced to dispose of the property at a loss; the Yetta Korman real-estate notes, on apartment-house property at 7302–7310 Georgia Avenue, NW., having a face value of $1,000, are being extended 3 years to October 5, 1944, with interest at 4½ percent.

The Secretary read to the Board certain proposed amendments to the bylaws, whose purpose is to (1) include in Article II, which lists the officers of the Academy and indicates the manner of their selection, the manner of selecting the Custodian and Subscription Manager of Publications, and (2) include in Article III, which gives the duties of these officers, a statement of the duties of the Archivist and of the Board of Editors. At the present time, the Custodian and Subscription Manager of Publications has his duties described in Article III, but there is no statement in Article II as to the manner of his selection. Contrariwise, the Archivist does not have his duties described in Article III, but there is in Article II a statement as to the manner of his selection. The duties of the Board of Editors are at present described in the Standing Rules of the Board. The Board instructed the Secretary to distribute copies of these amendments to each member of the Board, for appropriate action at the next meeting.

The meeting adjourned at 9:25 P.M.

306TH MEETING OF THE ACADEMY

The 306th meeting of the Academy was held in the Assembly Hall of the Cosmos Club at 8:15 P.M. on Thursday, October 16, 1941, with President CLARK presiding FRANCIS W. REICHELDERFER, Chief of the U. S. Weather Bureau, delivered an address entitled *Some famous weather maps.* In his talk, Commander REICHELDERFER discussed the first weather maps, traced the evolution of the modern weather map, and indicated the work involved in its preparation, and showed, by map, the weather conditions holding at the times of a number of noteworthy storms in this country. The importance of air-mass analysis in the work of the Weather Bureau was briefly described.

There were about 145 persons present. The meeting adjourned at 9:30 P.M. for a social hour.

370TH MEETING OF THE BOARD OF MANAGERS

The 370th meeting of the Board of Managers was held in the Library of the Cosmos Club on Friday, November 7, 1941. President CLARK called the meeting to order at 8:03 P M., with 20 persons present, as follows: A. H. CLARK, F. D. ROSSINI, N. R. SMITH, W. W. DIEHL, J. H. KEMPTON, J H HIBBEN, F C. KRACEK, J. E GRAF, F. H. H. ROBERTS, JR., F. G BRICK-WEDDE, H. B. COLLINS, JR., F. M SETZLER, R. M. HANN, A WETMORE, H. L. CURTIS, J. R. CHRISTIE, L. W. PARR, C L GARNER, and, by invitation, R J. SEEGER and G. A COOPER

The minutes of the 369th meeting were read and approved

President CLARK announced the following appointments: Committee to Consider the Policy for Future Editions of the Directory, H. L. CURTIS (chairman), F. C. KRACEK, L W. PARR, and F. H. H. ROBERTS, JR

Chairman KRACEK of the Committee on Membership presented nominations for membership for 7 persons, 6 resident and 1 nonresident

The Committee on Nominations, H E. McCOMB, chairman, reported that the following nominations for officers for 1942 had been made: For president, HARVEY L. CURTIS; for Secretary, FREDERICK D ROSSINI; for Treasurer, HOWARD S RAPPLEYE, for Manager, to January, 1945, with two to be elected, SIDNEY F BLAKE, ROBERT F. GRIGGS, FRANK C. KRACEK, and BEN H. NICOLET.

The Secretary reported the following data relating to the membership: Deaths, 1; acceptances to membership, 1; resignations, 2. The status of the membership as of November 6, 1941, is as follows:

	Regular	Retired	Honorary	Patrons	Total
Resident	433	33	3	0	469
Nonresident	128	18	13	3	162
Total	561	51	16	3	631

The amendments to the bylaws previously circulated to the Board were approved for submission to vote of the membership. The proposed amendments are as follows:

Article II

(1) In the second sentence of Section 1, interchange "4" and "5," and after "Manager of Publications" insert "(see Section 6)."

(2) Interchange the numbers and position of Sections 4 and 5.

(3) Add the following new Section· "Section 6 —The Custodian and Subscription Manager of Publications shall be appointed by the President for a period of three years."

Article III

(1) Change the number of the present Section 4 to Section 6

(2) As new Section 4, insert the following: "Section 4 —The Archivist shall maintain in good order all of the permanent records of the Academy These shall include the important records that have passed out of current use from the offices of the Secretary, Treasurer, etc , and such other documents and material as the Board of Managers may direct."

(3) As new Section 5 insert what is now Rule 7 of the Standing Rules of the Board of Managers: "Section 5 —The Board of Editors shall have charge of the Journal of the Academy The Senior Editor shall sign all contracts on behalf of the Journal Associate Editors shall be appointed by the President for a term of three years "

The meeting adjourned at 8:50 P.M

307TH MEETING OF THE ACADEMY

The 307th meeting of the Academy was held in the Assembly Hall of the Cosmos Club at 8:15 P.M. on Thursday, November 27, 1941, with President CLARK presiding MATTHEW W. STIRLING, Chief of the Bureau of American Ethnology of the Smithsonian Institution, assisted by Mrs. STIRLING delivered an illustrated address entitled *Treasure trove of Mexican archeology* The lecture described pictorially the National Geographic Society–Smithsonian Institution Archaeological Expedition to southern Mexico during the winter of 1940–41, which conducted excavations at the site of Cerro de las Mesas on the Rio Blanco in the southern part of the state of Veracruz, on the Isthmus of Tehuantepec, and at the site of Izapa on the Mexican side of the Guatemalan border near the town of Tapachula Of considerable interest was the report of the findings of the expedition, which included a cache of 782 jade objects and more than 30 stone monuments.

<div align="right">FREDERICK D. ROSSINI, Secretary.</div>

𝕺bituaries

HUGH McCORMICK SMITH died early in the morning of September 28, 1941, of an attack of coronary thrombosis after an illness of only a few hours. He was 75 years of age, having been born on November 21, 1865, in Washington, D. C., son of Thomas Croggon and Cornelia Hazard Smith.

Smith began his natural-history studies when a small boy, owing largely to his father's interest in birds and other animals on his farm in Virginia. He was the first president of the Natural History Society of Central High School, D. C., from which he was graduated in 1884. In 1888 he was graduated in medicine, with a perfect record in all oral and written examinations, from Georgetown University Medical School and was a member of its staff from 1888 to 1905.

Dr. Smith's interest in science was influenced and probably guided while he was in high school by Spencer F. Baird, who in 1884–85 gave him the opportunity to work in the National Museum He entered the service of the United States Fish Commission under Baird in 1886 and during the next six years had six promotions. He was co-special agent in charge of fisheries, United States Census of 1890. From 1893 to 1897 he was assistant in charge

of statistics and methods of the fisheries, United States Fish Commission, and during the next five years was assistant in charge, division of inquiry respecting food-fishes and the fishing grounds.

From 1903 to 1913 Dr. Smith was deputy commissioner of the Bureau of Fisheries, a position specially created by Congress, and from 1913 to 1922 he was the Commissioner of Fisheries. In 1900 he was named to represent the United States at the First International Fishery Congress, Paris; and again in 1905 at the Third International Fishery Congress at Vienna. He was secretary-general at the Fourth International Fishery Congress, Washington, in 1908.

Smith held several positions of honor, such as secretary, National Fishery Congress, 1898; chairman, International Jury on Fish Culture, Louisiana Purchase Exposition, 1904, expert adviser of the Food and Drugs Board and of the Bureau of Chemistry in fishery cases arising under the Pure Food and Drugs Act of 1906–13; expert special assistant of the United States Counsel at the Arbitration of the North Atlantic Fisheries Dispute at The Hague, 1910; United States Government representative of the International Commission for Adjudication of Fishery Disputes with Canada and Newfoundland arising under the award of The Hague arbitration tribunal, 1910; representative of the United States on the Permanent International Council for the Exploration of the Sea, 1912; member of the research committee and associate editor, National Geographic Society, 1909–19, commissioner on behalf of the United States on International Fishery Commission for regulation of fisheries in boundary waters of the United States and Canada, 1914. He was also director of the Marine Biological Laboratory of the United States Bureau of Fisheries, Woods Hole, Mass , 1901–02, and director of the *Albatross* expedition for investigation of fisheries and aquatic resources of the Philippine Islands, 1907–10.

From 1900 to 1934 he studied the aquatic resources and the fisheries, as well as inspected methods of fish culture, some of the laboratories, biological investigations, and fishery administrations, in 22 countries in Europe, South America, and Asia. The extensive collections made by Dr. Smith in these various lands and adjoining seas were given to various museums, but mostly to the United States National Museum.

This great naturalist was a member of no less than 15 scientific societies and contributed much to their advancement. He held the presidency for one or more years of the American Fisheries Society, the Biological Society of Washington, and the Cosmos Club of Washington, D. C. He was a fellow of the American Association for the Advancement of Science and honorary member of the following: Imperial Russian Society of Fish Culture and Fisheries, Imperial and Royal Austrian Fishery Society, and the Salmon and Trout Association of Great Britain and Ireland. In honor of his contributions to science, four birds, two reptiles, one amphibian, nine fishes, three mollusks, two crustaceans, two insects, and three other forms have been named for him. From 1898 to 1931 he was presented with seven honorary medals in recognition of his achievements and services.

Dr. Smith's chief contributions to science were in the fields of ichthyology and fisheries. In the latter field he spent 36 years with the United States Fish Commission, publishing about one hundred papers on fishery science; and a somewhat larger number on ichthyology have appeared under his name, describing numerous new species, new genera, and families of fishes. Among a total of about 300 published papers by him there is one or more in nearly all fields of natural history. Since 1925 his published researches were

largely on fishes and other animals from Siam, now Thailand, where from 1923 to 1935, as Adviser in Fisheries to his Siamese Majesty's Government, organizer of the Siamese fishery service and first director of the fishery bureau, he had ample opportunity to collect and study the fauna of that kingdom.

In addition to his official duties in Thailand he began collecting natural-history specimens in his spare time and sending them to the United States National Museum. In 1924 and again in 1926 he visited Koh Chang, a large mountainous island lying off the southeastern coast. On the mainland he covered all the territory fairly well from Patani in southern Peninsular Siam to the northern boundary and the eastern, southeastern, and southwestern parts of the country. Many of the localities were visited more than once and some several times. Although his chief interest while in Thailand was fishes, he sent 6,555 bird skins and bird skeletons to the United States National Museum besides thousands of other natural-history specimens. His interest in Siamese fishes was so great that upon his return to the United States in 1935 he began the most important scientific contribution of his life, "A Monograph of the Fresh-water Fishes of Siam." For the last six years this monumental work, with about 300 illustrations planned, occupied all his time in the division of fishes, United States National Museum, where he was associate curator in zoology. Although his untimely death left the Siamese manuscript not quite completed, it is being prepared for publication by one of his colleagues.

The death of Dr. Smith was a great shock to his family and to his numerous friends here and in many foreign countries. Through his death science has lost one of its great men. His kind nature and willingness to help students become established in their specialty made him dear to the hearts of many. To honor this great man, his friends had prepared to issue in November, 1941, an anniversary number of *Copeia* (the journal of the American Society of Ichthyologists and Herpetologists) on his 76th birthday, but much to the disappointment of all, this issue was published on November 21, 1941, as a memorial number. Dr. Leonhard Stejneger, in his tribute to Dr Smith in this memorial issue of *Copeia*, has excellently summarized Smith's life:

"When Dr. Smith, in 1886, joined the U. S. Fish Commission the connection with the Smithsonian Institution, with Baird as the head of both, was in many respects so close that it sometimes was difficult to draw the line between them, and when in 1935 the Institution took Smith to its heart as Associate Curator of Zoology, he was practically at home again. As U S. Commissioner of Fisheries Dr. Smith was Baird's worthiest successor, for he possessed in rich measure the same mental and spiritual qualities that inspired in all his associates, high and low, the respect, faith, admiration and love of which this note is only a feeble expression. In my heart two pictures stand side by side, Spencer Fullerton Baird and Hugh McCormick Smith, higher tribute I cannot conceive."

On March 12, 1889, Dr. Smith married Emma Hanford. Their daughters are Mrs. Edmund Vincent Cowdry, of St. Louis, and Mrs. Carl Harry Claudy, Jr., of Washington.

DAVID IVES BUSHNELL, JR., who died on June 4, 1941, enjoyed a notable career in American archaeology and ethnology. He was born in St Louis, Mo., on April 28, 1875, and his future interests were no doubt determined in some measure by the fact that his father, a very successful business man, was long connected with the Missouri Historical Society and president of

a local body of archaeologists that conducted investigations in and about St. Louis. In the fall of 1899, during a canoe trip through northern Minnesota, young Bushnell witnessed a Chippewa ceremony and made some notes regarding it afterward included in an article in the *American Anthropologist*. The year following he accompanied Jacob V. Brower on an expedition to explore mound groups and village sites along the shores of Mille Lac. He kept a diary during this period the essential parts of which were incorporated in a memoir bearing the joint names of the participants.

From 1901 to 1904 Bushnell was an assistant in archeology at the Peabody Museum, Harvard University, made a study of aboriginal salt works at Kimmswick, Mo., and completed a report on the great Cahokia mound group. From 1904 to 1907 he was in Europe, visiting in particular England, Switzerland, and Italy, where he made notes regarding a number of collections of American Indian objects in various museums and engaged in some archeological work.

After his return to the United States he and his mother lived for a time at Charlottesville, Va., but later they moved to Washington, and he became a collaborator in the anthropological work of the Smithsonian Institution, contributing five bulletins to the publications of the Bureau of American Ethnology, thirteen papers to the Smithsonian Miscellaneous Collections, five to the Annual Reports, and one to the Proceedings of the National Museum, besides making several minor contributions. He was instrumental in obtaining a copy of the journal of Rudolph Friederich Kurz which was edited by J. N B. Hewitt and printed as Bulletin 115 of the Bureau of American Ethnology He contributed many papers to *Man*, the *American Anthropologist*, the *Journal of the Washington Academy of Sciences*, and various other scientific and historical periodicals

In the winter of 1908–09 Bushnell made a study of a small group of Choctaw Indians living on Bayou Lacomb, La., but nearly all his later work consisted in archeological explorations in the neighborhood of Washington, though he made some collections on the Cape Fear River, N C , and in Florida. In 1921 he visited Scott Field, the flying field east of Belleville, Ill., to obtain airplane pictures of the Cahokia mounds. The photographers were Lt. Harold R. Wells and Lt. Ashley C McKinley He was particularly interested in the soapstone quarries and projected a bulletin on the primitive salt industry of the American Indians, which he did not live to complete.

During all this time Bushnell was engaged in forming a collection of paintings and sketches of Indian subjects by early artists, some of them almost unknown either to ethnologists or historians He projected a large work on artistic representations of Indians and Indian life in the period before 1875, but this undertaking also, for which he was supremely well prepared, was unfortunately cut off by his death.

Bushnell was possessed of a graceful style in writing. He exercised great care in the arrangement of his materials and was indefatigable in assembling the details for any work in which he was interested His archeological investigations were generally confined to limited areas, but he opened up many interesting problems. In the attention that he called to certain European collections of Indian artifacts and in his assemblage of sketches illustrative of Indian life he performed a unique service and placed all American anthropologists in his debt.

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